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भाग 1 निम्न प्रसार झाग

(पहला पुनरीक्षण)

Design and Installation of Fixed Foam Fire Extinguishing Systems — Code of Practice

Part 1 Low Expansion Foam

(First Revision)

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भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली – 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.gov.in www.standardsbis.in

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FOREWORD

This Indian Standard (Part 1) (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Firefighting Sectional Committee had been approved by the Civil Engineering Division Council.

Fixed fire extinguishing installations are employed for protecting public buildings and industrial premises where it is desired to keep fire losses to the minimum by automatic discharge of fire extinguishing media immediately upon an outbreak of fire particularly when the premises are unoccupied, such as during the night, weekends and holidays, and in particular parts of the premises where it is not possible to fight the fire manually. Such installations are also employed for fire protection in premises which are at times unattended. There are various types of fixed fire extinguishing installations, like carbon dioxide, sprinklers, dry powder, foam and halon. This standard covers the requirements of fixed foam fire extinguishing system. This standard was intended to be brought in two parts:

Part 1 covering low expansion foam installations; and

Part 2 covering medium and high expansion foam installations.

Fixed foam fire extinguishing installations are suitable as extinguishing system for the fire risk like flammable liquid processes and their storage areas, industrial chemical complexes, vehicle loading bays, etc. Such types of systems can also be used in aircraft hangars not exceeding 7.5 m in height or 1 600 m^2 in area. This standard gives guidance to those who are responsible for the selection, design, installation and maintaining such systems. Adherence of this standard will ensure that these systems are effective in controlling and extinguishing the types of fires for which they are designed.

The standard (Part 1) was first published in 1989 as a Code of practice for design and installation of fixed foam fire extinguishing system. Part 2 is under formulation.

In this revision, the following major changes have been made:

a) New type of foam known as bio-foam is included as a fluoro surfactant [in view of the gradual phasing out of perfluorooctane sulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) due to their non-biodegradability and carcinogenic potential].
b) Requirements for the installation of protection systems using low expansion foams have been detailed.
c) Detailed working mechanism and the method of application of foam fire extinguishing system have been included.
d) Limitations on use of low expansion foams have been updated.
e) New types of foam concentrates, such as film forming fluoroprotein foaming agents and alcohol type foaming agents have been included.
f) Design considerations and specifications for foam system have been updated.
g) Suitability of different types of foam to fight specific fires has been included in Annex E.
h) Terminology has been brought up-to-date.
j) All the cross-referred standards have been updated.

This revision of standard covers all relevant information regarding various types of foam, their application, design information and installation methods. Assistance has been derived from various documents such as:

ISO 7076-1 : 2012	Fire protection — Foam fire extinguishing systems — Part 1: Foam proportioning equipment
ISO 7076-2 : 2012	Fire protection — Foam fire extinguishing systems — Part 2: Low expansion foam equipment
NFPA 11 : 2016	Standard for low, medium, and high-expansion foam
NFPA 16 : 2019	Standard for the installation of foam-water sprinkler and foam-water spray systems
BS EN 13565-2 : 2018	Fixed firefighting systems — Foam systems — Design, construction and maintenance
BS 5306-1 : 2006	Code of practice for fire extinguishing installations and equipment on premises — Part 1 Hose reels and foam inlets

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Indian Standard

DESIGN AND INSTALLATION OF FIXED FOAM FIRE EXTINGUISHING SYSTEM — CODE OF PRACTICE

PART 1 LOW EXPANSION FOAM

(First Revision)

1 SCOPE

This standard (Part 1) lays down the requirements for design, installation, selection, inspection, operation and maintenance for both fixed and semi-fixed type of low expansion foam systems.

2 REFERENCES

The standards listed in Annex A contain provisions which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 TERMINOLOGY

For the purpose of this standard, the terms given in IS 7673 and IS 8757, and the following shall apply.

3.1 Application Rate — The rate at which foam solution is applied to a fire. Usually expressed in litres of foam-water solution per square metre of fire surface area per minute (l/min/m^2). For low expansion type of foam, the same is measured at the foam discharging branch pipe.

3.2 Adhesive Qualities — The ability to bind together substances of unlike compositions.

NOTE — When a foam blanket clings to a vertical surface, it is said to have adhesive qualities. For example, this is required to prevent vapour release from a tank shell.

3.3 Air-foam/Mechanical Foam — Foam produced by a physical agitation of a mixture of water, air and a foaming agent.

3.4 Accelerated Ageing — Storage of foam concentrates for short periods at high temperatures to indicate their long term storage properties at ambient temperatures.

3.5 Base Injection — The introduction of foam from beneath the surface of certain flammable hydrocarbons to effect extinguishment.

3.6 Boil-over — Violent ejection of flammable liquid from its container caused by the vapourization of water beneath the body of liquid. It may occur after a lengthy burning period of products, such as crude oil when the heat wave has passed down through the liquid and reaches the water bottom in a storage tank. It will not occur to any significant extent with water soluble liquids or light products, such as gasoline.

3.7 Bund Area — The tankage area bound on all sides by dyke walls.

3.8 Burn-back Resistance — The ability of a foam blanket to resist direct flame impingement as would be evident in a partially extinguished petroleum fire or re-ignition following an extinguishment.

3.9 Cohesive Qualities — The ability to bind together the substances of like composition. A good foam blanket is held together by its cohesive qualities.

3.10 Concentration — The percent of foam concentrate contained in a foam solution. The type of foam concentrate being used determines the percent of the concentration required. A one percent foam concentrate is mixed in the ratio of 99 parts water to 1 part foam concentrate to make foam solution. A three percent concentrate is mixed with 97 parts of water to 3 parts of foam concentrate. A six percent concentrate is mixed with 94 parts of water to 6 parts of foam concentrate.

3.11 Control — A reduction of fire intensity of approximately 90 percent.

3.12 Combustible Liquids — Combustible liquids shall mean any liquid having a flash point at or above 32 °C (90 °F). They may be further sub-divided as follows:

a) Class II liquids shall include those having flash points at or above 32 °C (90 °F) and below 65 °C (150 °F),

b) Class IIIA liquids shall include those having flash points at or above 65 °C (150 °F) and below 100 °C (212 °F), and

c) Class IIIB liquids shall include those having flash points at or above 100 °C (212 °F).

3.13 Class of Fires — There are four classes of fire namely, Class A fires in materials, such as wood, paper, clothes, etc; Class B fires involving a flammable liquids; Class C fires involving gases; Class D fires involving metals; and Class K or F fire involving fat fires or kitchen fires.

3.14 Critical Application Rate — The lowest rate at which foam solution may be applied to a fire in order to achieve extinction.

3.15 Discharge Device — A fixed, semi fixed or portable device that directs the flow of foam to the fire or flammable liquid surface. Also it is a device designed to discharge water or foam-water solution in a predetermined, fixed, or adjustable pattern. Examples include, but are not limited to, sprinklers, spray nozzles, hose nozzles, pourers, monitors, etc.

3.16 Discharge Coefficient — The coefficient K is given by the equation:

$K = QP^{-1/2}$ where Q is the flow (in m^3/h), and P is the pressure (in bar).

3.17 Dissolved Solids — Solid matters left after evaporating all water from a foam compound.

3.18 Drainage Time — Time taken for a percent of the concentrate content of a foam sample of a stated depth to drain to the bottom. For low and medium expansion foams, it is measured as 25 percent and high expansion foams it is 50 percent.

3.19 Drainage Rate — Rate at which water drains from a finished foam.

3.20 Deflector — A device attached to most type II fixed foam chamber discharge outlets which directs then flow of foam down and over the large area of the inside of the tank wall.

3.21 Downstream — Direction to which the water is flowing.

3.22 Expansion Ratio — Ratio of the volume of the foam solution to the volume of the foam produced after aeration.

3.23 Eductor — A device that uses the venturi principle to introduce a proportionate quantity of foam concentrate into a water stream. The pressure at the throat is below atmospheric pressure and will draw in liquid from atmospheric storage tank.

3.24 Flammable Liquids — Flammable liquids mean any liquid having a flash point below 32 °C (90 °F) and having a vapour pressure not exceeding 276 kPa at 32 °C (90 °F). Flammable liquids may be further sub-divided into:

a) Class IA liquids shall include those having flash points below 23 °C (73 °F) and having a boiling point below 32 °C (90 °F),
b) Class IB liquids shall include those having flash points below 23 °C (73 °F) and having boiling point above 32 °C (90 °F), and
c) Class IC liquids shall include those having flash points at or above 23 °C (73 °F) and below 32 °C (90 °F).

3.25 Flashback — Reignition of flammable liquid caused by exposure of vapours to a source of ignition, such as hot metal surface or a spark.

3.26 Foam Concentrate — Foam concentrate is a concentrated liquid foaming agent as received from the manufacturer. The following are the varieties of foam concentrates available (*see also* IS 4989):

a) Protein foam,
b) Fluoroprotein foam,
c) Synthetic foam, such as aqueous film forming foam, medium and high expansion foams and other synthetic concentrate foams,
d) Film forming fluoroprotein foam,
e) Alcohol resistant foam, and
f) Biofoam.

3.27 Foam — A firefighting agent made by mechanically mixing air with a solution consisting of fresh/hard/soft/sea/potable water to which a foaming agent (liquid concentrate) has been added. Firefighting foam is a stable aggregation of small bubbles of lower density than oil or water, and shows tenacious qualities for covering horizontal surfaces.

3.28 Foam Quality — A measure of foams physical characteristics, expressed as:

a) 25 percent drain time; and
b) expansion ratio.

3.29 Foam Solution — A mixture of proportioned of pre-mixed foam liquid concentrate dissolved in fresh/hard/soft/sea water.

3.30 Foam Proportioning — Proportioning is the continuous introduction of foam concentrate at the recommended ratio into the water stream to form foam solution.

3.31 Foam Water Sprinkler System — A special system that is pipe-connected to a source of foam concentrate and to a water supply. The system is equipped with appropriate discharge devices for extinguishing agent discharge and for distribution over the area to be protected. The piping system is connected to the water supply through a control valve that usually is actuated by operation of automatic detection equipment that is, installed in the same areas as the sprinklers. When this valve opens, water flows into the piping system, foam concentrate is injected into the water, and the resulting foam solution discharging through the discharge devices generates and distributes foam. Upon exhaustion of the foam concentrate supply, water discharge follows and continues until shut off manually. Systems can be used for discharge of water first, followed by discharge of foam for a specified period, and then followed by water until manually shut off. Existing deluge sprinkler systems that have been converted to the use of aqueous film-forming foam or film-forming fluoroprotein foam are classified as foam-water sprinkler systems. Other types of systems are as follows:

a) *Foam-Water Deluge System* — A foam-water sprinkler system employing open discharge devices, which are attached to a piping system that is connected to a water supply through a valve that is opened by the operation of a detection system, which is installed in the same areas as the discharge devices. When this valve opens, water flows into the piping system and foam discharges from all discharge devices attached thereto.

b) *Foam-Water Dry Pipe System* — A sprinkler system employing automatic sprinklers or nozzles that are attached to a piping system that contains air or nitrogen under pressure, the release of which (as from the opening of a sprinkler) permits the water pressure to open a valve known as a dry pipe valve. The foam solution then flows into the piping system and out the opened sprinklers.

c) *Foam-Water Preaction System* — A sprinkler system employing automatic sprinklers or nozzles attached to a piping system containing air that might or might not be under pressure, with a supplemental detection system installed in the same area as the sprinklers. Actuation of the detection system opens a valve that permits foam solution to flow into the sprinkler piping system and to be discharged from any sprinklers that have activated.

d) *Foam-Water Spray System* — A special system that is pipe-connected to a source of foam concentrate and to a water supply. The system is equipped with foam-water spray nozzles for extinguishing agent discharge (foam followed by water or in reverse order) and for distribution over the area to be protected. System operation arrangements parallel those for foam-water sprinkler systems as described in the definition of foam-water sprinkler system.

3.32 Foam Water Density — The unit rate of foam water solution application to an area expressed in litre/metre^2.

3.33 Full Scale Equipment — Field installed components, such as proportioners and foam makers, that are intended to extinguish fires.

3.34 Foam Maker — A device designed to introduce air into a pressurized foam solution stream.

3.35 Foam Stability — The relative ability of a foam to withstand spontaneous collapse or breakdown from an external causes, such as heat or chemical reaction.

3.36 Friction Loss — The loss of pressure in a flowing stream resulting from resistance to flow imposed by the inside of the pipe or hose and by changes in flow directions, such as elbows and tees.

3.37 Head Loss — Pressure necessary to force water up a pipe or hose to a given vertical height above the source of water pressure.

3.38 High Expansion — Foam of expansion ratio 200 to 2 000.

3.39 Hydrocarbon Fuels — Fuels containing primarily hydrogen and carbon atoms; for example, petrol, oil, etc.

3.40 Heat Resistance — The ability of a foam to withstand its exposure to heat.

3.41 Hydrophilic — Water liking; mixing readily with water.

3.42 Hydrophobic — Water hating; having the property of not mixing with water.

3.43 Induction Rate — The percent of foam compound mixed or induced into the water supply to achieve a solution.

3.44 Liquid Concentrate — A concentrated protein or synthetic liquid foaming agent that is intended to be diluted with fresh water at a concentration (volume of concentrate/volume of water) of 1 percent or higher.

3.45 Low Expansion — Foam of expansion ratio between 2 and 20.

3.46 Medium Expansion — Foam of expansion ratio between 20 and 200.

3.47 Minimum Operating Temperature — The lowest temperature at which a foam concentrate will proportion with venturi devices.

3.48 Non-aspirated Foam — Foam of expansion typically between 0 and 2. Only film forming compounds are suitable.

3.49 Nozzle — A device intended to discharge foam in a straight stream or other specific pattern. In field application, a nozzle may be handheld or fixed in position.

3.50 Oleophobic — Oil hating; having the ability to shed gasoline, oil and similar products.

3.51 Pick Up — The induction of a foam concentrate into a water stream by a venturi equipment.

3.52 *p*H Value — Measurement of acidity to alkalinity on a scale of 1 to 14. Neutral and deionized water has a *p*H value of 7.

3.53 Polar Solvent — These are generally water miscible solvents which require special foam compounds, for example, alcohols, esters, ethers, aldehydes, and ketones. In firefighting parlance, any flammable liquid which destroys regular foam is generally referred to as a polar solvent. Generally such liquids possess a permanent dielectric charge.

3.54 Polymeric Membrane — A thin, durable cohesive skin formed on a polar solvent fuel surface, protecting the foam cells by destruction by the fuel, a coagulation which occurs when a polar solvent foam comes in contact with a hydrophilic fuel such as isopropanol, ethanol or other solvents.

3.55 Pressure Drop — The net loss in flowing water pressure between any two points in a hydraulic system. It is the sum of friction loss of pipes and all fittings, head loss, or other losses due to the insertion of an orifice plate, venturi, or other restriction into a section of pipe or hose.

3.56 Protein — Complex nitrogen containing organic compounds derived from natural vegetable or animal sources. Hydrolysis products of protein provide exceptionally stable, cohesive, adhesive and heat resistant properties to foams.

3.57 Pour Point — The lowest temperature at which a foam compound is fluid enough to pour, generally a few degrees above freezing point.

3.58 Protein Type Concentrate — A hydrolized protein based low expansion foam liquid.

3.59 Proportioning — Proportioning is the continuous introduction of foam concentrate at the recommended ratio into the water stream to form foam solution.

3.60 Proportioners — The methods to provide suitable proportioning of foam liquid concentrate and water through known mechanisms, such as direct injection variable pump output proportioning, foam nozzle eductor, inline inductor, balanced pressure pump type proportioning, in-line balanced pressure proportioning, around the pump proportioning, etc.

3.61 Regular Liquid Concentrate — A low expansion protein or synthetic foam liquid used in the production of foam and intended to extinguish fires involving common flammable hydrocarbon liquids, such as heptane, that are not miscible in water.

3.62 Residual Pressure — The pressure existing in a line at a specified flow (as opposed to static pressure).

3.63 Self Aspirating — A foam producing equipment into which air is introduced by the venturi effect of the foam solution stream.

3.64 Self Inducting — A foam proportioning device into which the foam concentrate is introduced by the venturi effect of the water stream.

3.65 Shear Stress — The measurement of the stiffness of the foam sample in a viscometer measured, in N/m^2.

3.66 Skin Fire — A flammable liquid fire, such as a spill on a solid surface where the liquid is not present in a depth not exceeding 300 mm.

3.67 Solution Transit Time — The time taken for the solution to pass from the point where foam compound is introduced to the water supply to where aeration takes place.

3.68 Spray Nozzle — A device intended to discharge foam in a fixed spray pattern and attached to piping.

3.69 Spray Pattern — The pattern produced by a widely divergent flow of fully formed subdivided foam, the pattern varying with nozzle pressure and the adjustment of the spray creating device.

3.70 Sprinkler — A device intended for installation in an upright or pendent position, designed to distribute foam or water downwards in an umbrella shaped pattern.

3.71 Stability — A term used with foam concentrates to determine the permanence and security of a foam blanket.

3.72 Static Pressure — A pressure existing in a line at no flow. This can be considered as higher than the residual pressure.

3.73 Submergence — Plunging of foam beneath the surface of burning liquid, resulting in partial breakdown of the foam structure and coating of the foam with the burning liquid.

3.74 Subsurface Foam Injection — Discharge of foam into certain flammable hydrocarbon storage tanks from outlets near the tank bottom.

3.75 Surfactant — A chemical that lowers the surface tension of a liquid. Also known as surface active agents.

3.76 Specific Gravity — It is a measure of the density of the material in relationship to the density of water.

3.77 Topside Application — A method of foam discharge wherein the foam is applied onto the top of the burning fuel surface.

3.78 25-Percent Drain Time — The time required for 25 percent of the liquid contained in the foam to drain.

3.79 Transalem Closure or Vapour Seal — A specially designed rupturable seal used in foam chambers which prevents vapours within the tank from entering the foam solution lines.

3.80 Types of Foam Concentrates

3.80.1 *Alcohol Type Liquid Concentrate* **—** A concentrate used for fighting fires on water-soluble materials and other fuels destructive to regular, AFFF, or FFFP foams, as well as for fires involving hydrocarbons.

3.80.2 *Aqueous Film-forming Foam (AFFF) Type Liquid Concentrate* **—** A concentrate based on fluorinated surfactants plus foam stabilizers and usually diluted with water to a 1 percent, 3 percent, or 6 percent solution.

3.80.3 *Fluoroprotein Foam Concentrate* **—** A concentrate very similar to protein-foam concentrate but with a synthetic fluorinated surfactant additive. In other words, a foam compound based on hydrolized protein with surface active fluorocarbon surfactants added and loosely bonded to provide oleophobicity.

3.80.4 *Film Forming Foam* **—** A concentrate that when mixed at its nominal use concentration will form an aqueous film on hydrocarbon fuels. The hydrocarbon fuel typically used as a minimum benchmark for film formation is cyclohexane.

3.80.5 *Film-forming Fluoroprotein Foam Concentrate* (*FFFP*) **—** A concentrate that uses fluorinated surfactants to produce a fluid aqueous film for suppressing hydrocarbon fuel vapors.

3.80.6 *Protein Foam Concentrate* **—** Concentrate consisting primarily of products from a protein hydrolysate, plus stabilizing additives and inhibitors to protect against freezing, to prevent corrosion of equipment and containers, to resist bacterial decomposition, to control viscosity, and to otherwise ensure readiness for use under emergency conditions.

3.80.7 *Medium and High-expansion Foam Concentrate* — A concentrate, usually derived from hydrocarbon surfactants, used in specially designed equipment to produce foams having foam-to-solution volume ratios of 20 : 1 to approximately 1 000 : 1.

3.80.8 *Synthetic Foam Concentrate* — Concentrate based on foaming agents other than hydrolyzed proteins and including aqueous film-forming foam (AFFF) concentrates, medium and high-expansion foam concentrates, and other synthetic foam concentrates.

3.80.9 *Other Synthetic Foam Concentrates* **—** A concentrate based on hydrocarbon surface active agents and listed as a wetting agent, foaming agent, or both.

3.81 Types of Foam Systems

3.81.1 *Fixed System* — A complete installation in which foam is piped from a central foam station, discharging through fixed delivery outlets to the hazard to be protected with permanently installed pumps where required.

3.81.2 *Mobile System* — Any type of foam-producing unit that is mounted on wheels and that is self-propelled or towed by a vehicle and can be connected to a water supply or can utilize a premixed foam solution.

3.81.3 *Portable System* **—** Foam-producing equipment, materials, hose, and so forth, that are transportable manually.

3.81.4 *Semifixed System* **—** A system in which the hazard is equipped with fixed discharge outlets connected to piping that terminates at a safe distance.

3.82 Types of Foam Discharge Outlets

3.82.1 *Type I Discharge Outlet*

A device that conducts and delivers foam onto the burning surface of the liquid without submerging the foam or agitating the foam.

3.82.2 *Type II Discharge Outlet*

A device that delivers foam onto the burning liquid and partially submerges the foam and produces restricted agitation of the surface.

3.82.3 *Type III Discharge Outlet*

A device that delivers foam in a manner that causes the foam directly onto the surface of the burning liquid and does so in a method that causes general agitation.

3.83 Upstream — In the direction from which the water is flowing.

3.84 Unstable (Reactive Liquid) — A liquid that will vigorously polymerize, decompose, condense, or will become self-reactive under certain conditions of shock, pressure, or temperature.

3.85 Venturi — A constricted portion of a pipe or tube which increases water velocity, thus momentarily reducing its pressure.

NOTE — It is in this reduced pressure area, foam concentrate is introduced.

4 GENERAL

4.1 Foam for fire protection is an aggregate of air filled bubbles formed from aqueous solutions of specially formulated concentrated liquid foaming agents and is lower in density than flammable liquids. Normally the gas used is air, but in certain applications it may be an inert gas. Since foam is lighter than the aqueous solutions from which it is formed, and lighter than flammable liquids, it floats on flammable and combustible liquids, producing an air excluding, cooling, continuous layer of vapour sealing, water bearing material that halts or prevents combustion. Foam is produced by mixing a foam concentrate with water at the appropriate concentration, and then aerating and agitating the solution to form the bubble structure. Some foams are thick and viscous and form tough, heat resistant blankets over burning liquid surfaces and vertical areas. Other foams are thinner and spread more rapidly.

4.2 Foam is used principally to form a cohesive floating blanket on flammable and combustible liquids and prevents or extinguishes fire by excluding air and cooling the fuel. It also prevents re-ignition by suppressing formation of flammable vapours. It has the property of adhering to surfaces, which provides a degree of exposure protection from adjacent fires. Foam can be used as a fire prevention, control, or extinguishing agent for flammable liquid hazards. Foam for these hazards can be supplied by fixed piped systems or portable foam-generating systems. Foam can be applied through foam discharge outlets, which allow it to fall gently on the surface of the burning fuel. Foam can also be applied by portable hose streams using foam nozzles or large-capacity monitor nozzles or subsurface injection systems.

4.3 Some foams are capable of producing a vapour sealing film of surface active water solution on a liquid surface. Some foams, such as medium and high expansion foams are meant be used as large volumes of wet gas cells for inundating surfaces and filling cavities. Normally, foams are defined by their expansion ratio, which is the ratio of final foam volume to original foam solution volume before adding air. They are generally divided into three ranges:

a) Low expansion foam – expansion 20 : 1;
b) Medium expansion foam – expansion 20 : 1 to 200 : 1; and
c) High expansion foam – expansion 200 : 1 to 1 000 : 3.

In this standard (Part 1), the requirements for the installation of protection systems using low expansion foams are covered.

4.4 Foams are also defined according to their effectiveness on hydrocarbon fuels, water miscible fuels or both. Foam breaks down and vapourizes its water content under attack of heat and flame. It must, therefore, be applied to a burning liquid surface in sufficient volume and rate to compensate for this loss, with an additional amount applied to guarantee a residual foam layer over the extinguished liquid. Foam is unstable and may be broken down easily by a physical or mechanical force, such as a water hose jet stream. Certain chemical vapours or fluids may also destroy foam quickly. When certain other extinguishing agents are used in conjunction with foam, severe breakdown of the foam may occur. Turbulent air or violently uprising combustion gases may divert foam from the burning area.

4.5 Generally speaking, the following criteria for the flammable and hazardous liquids shall be met for a foam protection to be fully effective:

a) Combustible liquid shall not be water reactive.
b) At the ambient conditions of temperature and pressure, the combustible liquid shall be below its boiling point.
c) Liquid shall not be unduly destructive to the foam used, or in other words, the foam shall not be highly soluble in the liquid to be protected.
d) Foam application cannot extinguish three dimensional (falling fuel) or pressure fires in most of the cases. For effectiveness of the foam system, the fire shall be a horizontal surface fire.
e) From the standpoint of forming a cohesive foam blanket and rapid flow around the obstructions, a free flowing fluid type foam is desirable. But water from this type of foam is lost rapidly and chance of flame burn back is a possibility. From the other standpoint of foam that retain its water for a long time, it does not flow readily over the burning space, thus reducing the rapidity of fire extinction.

4.6 Thus the installation of foam system is really a compromise between these two opposite properties in order to obtain a premium optimum protection. Thus an optimum foam protection is defined as the foam, with physical properties defined by expansion and drainage time that will extinguish a fire faster, at a lower application rate or with less water consumed than any other foam.

4.7 Low expansion foams are generally used for the extinction of fires in flammable liquids by the formation of a blanket over the surface of the liquid, thereby reducing the rate of release of flammable vapours to the combustion zone below that which is necessary to maintain burning. The fires may include pool of spill fires, or fires in tanks and similar containers.

4.8 Low expansion foams may be applied directly to the surface of the burning liquid (surface application) or may be applied in the case of tank fires, below the surface so that they float to the surface under their own buoyancy (sub-surface application). Low expansion foams may also be applied by a semi sub-surface method. For petrol and light crude oils, (AFFF) should be used.

4.9 Low expansion foams may be used for the suppression of vapour emission from spillage of flammable liquids. They can also be used to protect other risks from radiant heating, provided the foam layer is regularly replenished, and they can have a limited usefulness in the extinction of surface fires in solid combustibles.

Spreading coefficient of the foam directly influences the ability of foam to spreads over the surface of a hydrocarbon fuel, cooling the burning fuel surface, reducing the hydrocarbon evaporation rate and depleting the supply of fuel vapour to the flames.

4.10 There are certain limitations on the use of low expansion foams and the same are listed as under:

a) They are not generally suitable for the extinction of running fuel fires, that is, fuel running from a leaking container or from damaged pipework or pipe joints.
b) Since all firefighting foams are made from aqueous solutions, they may be ineffective or dangerous to use on flammable liquids with temperatures having content of varying boiling point, much in excess of 100 °C, particularly where these fires are in liquids of considerable depth of in-tank fires. Drainage of the water from the foam may result in the formation of steam which can cause frothing or slop-over of the burning liquid unless due precautions are taken to avoid this. Foams, may, however, sometimes be used to cool the surface layers of a flammable liquid below the fire point, provided the temperature is not greatly in excess of 100 °C.
c) Most aqueous foams are not suitable for use on water-miscible flammable liquids, which can cause rapid breakdown of the foam by extraction of the water from the bubble walls. For these flammable liquids, specially stabilized foam concentrates are used.
d) Low expansion foams are not suitable for use on fires involving gases, or liquifiable gases with boiling points below 0 °C, or cryogenic liquids, however high expansion foam exhibits potential of managing fire involving cryogenic fluid like LNG, ethylene, etc. Also, low expansion foam is rendered ineffective in suppression of vapour generation from spillage of hazardous material (strong alkali or acid).
e) Because foams are made from aqueous solutions they may be dangerous to use on materials which react violently with water, such as metallic sodium or potassium.
f) Low expansion foam is a good conductor and should not be used on energized electrical equipment.
g) Certain wetting agents and some extinguishing powders may be incompatible with foams, causing a rapid breakdown of the latter. Only agents which are substantially compatible with these foams should be used in conjunction with them. In such cases AFFF should only be used.
h) Only certain types of foam concentrates are suitable for storage in the diluted or premixed condition. AFFF can be kept in premixed condition up to 1 year. Protein base foams are unsuitable for keeping in premixed condition.
j) Simultaneous use of water jets or sprays may adversely affect a foam blanket, and their use should not be envisaged in conjunction with these foams unless it has been shown that this will not occur.

The various types of foam (*see* IS 4989) available for protection of risks are as briefed under:

1) Protein foam,
2) Fluoroprotein foam,
3) Synthetic foam, such as aqueous film foaming foam, medium and high expansion foams and other synthetic concentrate foams,
4) Film foaming fluoroprotein foam,
5) Alcohol resistant foam, and
6) Biofoam.

4.11 The selection of foam, the method of application, foam application rate, type of foam pourers, installation of piping network, etc, depend on several factors on a case to case basis and it is not true that some philosophy of protection can be adopted for all fire protection requirement. Certain guidelines have been provided in this regard in this standard.

4.12 These provisions provide a reasonably sound protection philosophy for various types of risks with foam protection.

NOTE — Nothing in this standard is intended to restrict new technologies or alternate arrangements, provided the level of safety prescribed herein is not lowered.

5 TYPES OF FOAM CONCENTRATES

5.1 General

There are a number of foaming agents available and their application depends upon the type of hazard to be protected. While some are capable of extinguishing all types of flammable liquids, few of them are restricted for application only on specific types of liquids. Descriptions of some of the most commonly preferred foam agents are as under (*see also* Annex E).

5.1.1 *Protein [P] Foaming Agents*

a) Protein foams (*see* IS 4989) use aqueous liquid concentrates proportioned with water for their generation.

b) These concentrates contain high molecular weight natural proteinaceous polymers derived from a chemical digestion and hydrolysis of natural protein solids. The polymers give elasticity, mechanical strength and water retention capability to foams generated from them. The concentrates also contain dissolved polyvalent metallic salts which aid the protein polymers in their bubble-strengthening capability when the foam is exposed to heat and flame.

c) Protein type concentrates are available for proportioning to a final concentration of either 3 percent or 6 percent volume, using either fresh water or sea water.

d) In general, these concentrates produce dense, viscous foams of high stability, high heat resistance and also good resistance to burn-back. They are less resistant to breakdown by fuel saturation than are by other types of foams like AFFF and fluoroprotein foams.

e) These are non-toxic and bio-degradable. The normal-use ambient temperature range for these concentrates are between – 5 °C and 50 °C. These type of concentrates are relatively less expensive compared to other type of foams.

f) Protein foams are not suitable for use in sub-surface systems in fuel storage tanks but may be, applied by a semi subsurface method.

g) Protein foams are compatible with certain dry chemicals.

5.1.2 *Fluoroprotein [FP] Foaming Agents*

a) The concentrates used for generating fluoroprotein foams are similar in comparison to protein foam concentrates, but, in addition to protein polymers, they contain fluorinated surface active agents that provides a 'fuel shedding' property to the generated foam.

b) This makes them particularly effective for firefighting conditions where the foam becomes coated with fuel, such as in the method of sub-surface injection of foam for tank firefighting, and nozzle or monitor foam applications where the foam may be often plunged into the fuel.

c) This type of foam is thus very effective for in-depth crude petroleum or other types of hydrocarbon fuel fires due to its 'fuel shedding' property. They also possess superior securing and burn back resistance.

d) Fluoroprotein type concentrates are available for proportioning to a final concentration of either 3 percent or 6 percent volume, using either fresh water or sea water.

e) These are non-toxic and bio-degradable after dilution. The normal-use ambient temperature range for these concentrates are between – 5 °C and 50 °C.

f) These foams are reported to have better compatibility with dry chemical powders when used as combined agent systems.

5.1.3 *Film Forming Fluoroprotein [FFFP] Foaming Agents*

a) Film forming fluoroprotein [FFFP] foaming agents are composed of protein together with film-forming fluorinated surface active agents, which make them capable of forming water solution films on the surface of most of the flammable hydrocarbons and conferring a 'fuel shedding' property to the generated foam.

b) However, for extinguishment, an effective FFFP blanket should cover the entire fuel surface.

c) The foams produced drain rapidly and may thus have less burn back resistance compared to protein based foams.

d) FFFP type concentrates are available for proportioning to a final concentration of either 3 percent or 6 percent volume, using either fresh water or sea water.

e) These foams are reported to have no compatibility problems with certain dry chemical powders when used as combined agent systems.

5.1.4 *Aqueous Film Forming [AFFF] Foaming Agents*

a) Aqueous film forming [AFFF] foaming agents are composed of synthetically produced materials that form foams similar to protein based foams. In addition, these agents are capable of forming water solution films on the surface of flammable hydrocarbon liquids, thus bringing the term 'aqueous' to its name.

b) The foams generated from AFFF solutions possess low viscosity, have fast spreading and levelling characteristics and just as other foams act as surface barriers to exclude air and prevent vapourization. These foams develop a continuous aqueous layer of solution under the foam, maintaining a floating film on hydrocarbon fuel surfaces to help not only suppress combustible vapours but also cool the fuel substrate.

c) Film effectiveness may be reduced on hot surfaces and aromatic hydrocarbons.

d) AFFF film fluidity and film strength on kerosene makes it suitable for fighting fires of aviation fuels. The extremely low surface tension of the solution draining from AFFF helps tackling fires under mixed class situations (Classes A and B), where deep penetration of water is needed in addition to the surface spreading action of the foam itself.

e) The foams produced drain rapidly and may thus have less burn back resistance compared to protein based foams.

f) These foams are reported to not seem to have compatibility issues with dry chemical powders when used as combined agent systems.

g) The normal-use ambient temperature range for these foam concentrates is between – 10 °C and 50 °C.

h) Sophisticated equipment are not required in the deployment of AFFF. Water spray nozzles and sprinklers may be used because of the inherent rapid and easy foaming capability of AFFF solutions.

j) AFFF type concentrates are available for proportioning to a final concentration of either 1 percent, 3 percent or 6 percent volume, using either fresh water or sea water.

k) Degradabality, high shelf life, as well as carcinogenic nature is presently been found a problem in its use and contamination. However AFFF, FP, FFFP, AR are not biodegradable.

5.1.5 *Alcohol Type Foaming Agents [AR]*

Foams generated from ordinary agents are subject to rapid breakdown and loss of effectiveness when they are used on fires that involve fuels that are water soluble water miscible, or of a 'polar solvent' type. Examples, of this type of fuel are alcohols, enamels, lacquers, thinners, etc. Even small amounts of these substances mixed with common hydrocarbon fuels, such as gasohol, may cause rapid breakdown of ordinary firefighting foams. Therefore, certain special foaming agents, called 'alcohol type concentrates' have been developed.

These alcohol resistant concentrates are proprietary compositions of several types some containing protein, fluoroprotein or an aqueous film forming foam concentrated base. The most common are usually described as polymeric alcohol resistant AFFF concentrates which produce foams suitable for application to spill or in-depth fires of either hydrocarbon or water miscible flammable liquids by any foam generating device.

There are three general types. One is based on water-soluble natural polymers, such as protein or fluoroprotein concentrates, and also contains alcohol-insoluble materials that precipitate as an insoluble barrier in the bubble structure. Second type is based on synthetic concentrates and contains a gelling agent that surrounds the foam bubbles and forms a protective raft on the surface of water-soluble fuels; these foams can also have film-forming characteristics on hydrocarbon fuels. Third type is based on water-soluble natural polymers, such as fluoroprotein, and contains a gelling agent that protects the foam from water-soluble fuels. This foam can also have film-forming and fluoroprotein characteristics on hydrocarbon fuels. Alcohol-resistant foam concentrates are generally used in concentrations of 1 percent to 10 percent solutions, depending on the nature of the hazard to be protected and the type of concentrate.

The normal-use ambient temperature range for these concentrates are between 2 °C and 50 °C.

Annex B serves as a guide for determining the suitability of different types of foams for variety of firefighting applications.

5.2 Requirements Pertaining to Foam Concentrates

5.2.1 *Foam Concentrate and Solution*

The pre-mixed foam solution used in the system shall have a concentration within the range of minus zero (0) percent, plus thirty (30) percent of induction rate (that is 1 or 3 or 6 percent) or one percent point, whichever is less. For sub-surface application, AFFF, FFFP or FP type of foams shall only be used. The nominal concentration of use for mixtures of foam concentrates shall not be less than the higher or highest value selected for design (1 percent, 3 percent or 6 percent as applicable).

5.2.2 *Supply of Foam Concentrates*

The minimum quantity of foam concentrate which shall be held in immediate readiness for a particular risk or hazard is determined by the following equation:

$$\text{Minimum quantity of foam concentrate (in litre)} = ABCD/100$$

where

A = area, in m^2;

B = application rate, in l/min/m^2;

C = percent foam concentrate, in percent; and

D = minimum discharge time, in min.

Suitable allowance shall be made for the quantity of foam concentrate needed to fill the pipelines between the source and the injecting devices. Where it is desired to continue the water supply after the foam concentrate is exhausted in order to displace the solution or concentrate in the feed lines, no additional concentrate need be provided.

The hazard requiring the greatest quantity of foam concentrate within the protected premises shall be thus identified (sum of the quantities indicated above) and equal quantity thus calculated shall be held in stock in readiness.

NOTE — Suitable reserve of supply shall be stored in stores.

5.2.3 *Storage of Foam Concentrates*

Foam concentrate and pre-mixed solutions of foam shall be stored at an accessible location not exposed to the hazard it protects. The storage shall be housed within a non-combustible structure. Only suitable concentrates shall be stored as pre-mixed solutions as high storage temperatures may accelerate deterioration due to aging of the solution. Means shall be available to ensure that the concentrate or pre-mixed solutions is kept within its design operating temperature range. Storage vessels shall be clearly marked with the class of concentrate and its concentration in the solution. Storage tanks shall have sufficient ullage space to accommodate thermal expansion of the concentrate or solution.

Adequate measures shall be adopted as per manufacturer recommendation to minimize the evaporation losses of foam during storage. The storage temperature and other storage condition shall comply with relevant standards and manufacturer's recommendations in all respect.

Foam storage tank shall be equipped with the appropriate level gauge and low level warning alarm.

5.2.4 *Foam Concentrate Compatibility*

Different types of foam concentrates shall not be mixed for storage. Low-expansion foams generated separately from protein, fluoroprotein, FFFP, and AFFF concentrates shall be permitted to be applied to a fire in sequence or simultaneously.

NOTE — The extinguishing effect of premixed solutions, in storage vessels or pipework, may be reduced considerably depending on the storage time and the quality of water used. Polymeric film forming foams should not be pre-mixed unless written confirmation of suitability has been provided by the foam manufacturer.

5.2.5 *Foam Concentrate Pumps*

Pumps for foam concentrate shall be either positive displacement pump like internal rotary gear pump or centrifugal type self-priming and driven by any suitable prime mover conforming to relevant Indian Standard. Foam concentrate pumps shall be treated as good as main fire pumps. Pumps shall have adequate capacity to meet the maximum system requirements. To ensure positive injection, the discharge pressure rating at design discharge capacity shall be sufficiently in excess of the maximum water pressure under any condition at the point of injection of the concentrate. Pumps shall be provided with adequate means of pressure and flow relief from the discharge to the suction side of the circuit to prevent excessive pressure and temperature. The material of construction for the moving parts of the pump shall be of non-corrosive type as specified in IS 13039. Special attention shall be paid to the type of seal or packing used. Seals or packing used shall be compatible with the foam concentrate. Installation of pumps should be as per manufacturer's recommendations and/or as per the Authority having jurisdiction (AHJ). However, various provisions of IS 13039 shall receive attention particularly for the electrification of pump motor and location of the foam concentrate pumps. Where hydrant pump water flow is utilized for the foam induction including online booster pumps if any, the hydrant system shall be of an approved type complying in all respects with various provisions of IS 13039. Pumps that are arranged to stand dry shall have means provided for flushing with clean water after use and shall be provided with a drain valve. Where required, all electrical equipment and fittings related to foam pumps shall be of flame-proof type. The electrical supply to foam pumps or fire pumps feeding the foam system shall comply with all the requirements specified in the fire protection manual for the purpose.

5.2.6 *Foam Proportioning Devices*

Devices shall be of approved type and selected from any of the following methods:

a) Self educting nozzle,
b) In-line inductor,
c) Pressure proportioners,
d) Around the pump proportioner,
e) Direct injection from variable output pump, and
f) Balanced pressure pump type proportioners.

5.2.7 *Water Supply*

Water supplies for the foam installations shall be free from suspended, fibrous or other matters, which may accumulate in the system pipework, and it is recommended to use filtered water for the system. The water supply to foam systems shall be permitted to be hard or soft, fresh or salty, but shall be of a quality such that adverse effects on foam formation or foam stability do not occur. System shall be normally charged with fresh water. Storage quantity shall depend upon the supply to all the devices on the assumption that all devices work simultaneously. This will be in addition to water quantity requirements for all other water based systems in the premises.

5.2.8 *Drainage of Bunds*

Drains and interceptors in bunded areas shall be of adequate capacity to carry the anticipated drainage of water/foam used for firefighting.

6 DESIGN REQUIREMENTS FOR FOAM SYSTEM

6.1 General

Fire protection, employing foam based system, can be achieved by different types of application depending upon the nature and type of the risks to be protected. The different types of application are listed as under:

a) Fixed systems,
b) Semi-fixed systems,
c) Portable systems, and
d) Mobile systems.

6.1.1 *Fixed Systems*

This type has permanent metallic pipework connected from the water supply *via* the fire water pump (if fitted) and foam liquid proportioning device to the foam producing equipment which protects the fire hazard.

6.1.2 *Semi-Fixed Systems*

Permanent metallic pipework is employed from an area adjacent to the risk, from which it is considered safe for personnel to conduct firefighting operations, to the foam producing equipment which protects the fire hazard. This pipework may include the proportioning device and has provisions for water supply hoses to be connected. The water supply is usually pumped and foam concentrates provided by mobile fire appliances.

6.1.3 *Portable Systems*

This includes foam producing units that can be carried by one or more men and connected *via* fire hose to a pressurized water or pre-mixed solution, so as to produce foam jets, or sprays that can be applied to the risks.

6.1.4 *Mobile Systems*

This includes foam producing units mounted on wheels, and which may be self-propelled, towed by a vehicle or pushed by hand. These units may be connected to a suitable water supply or may utilize pre-mixed foam solutions. They can produce foam jets or sprays that can be applied to the risk.

6.2 Important Design Considerations

The design of a foam system shall be made to suit hazards under consideration. The following points are to be considered before designing the system:

a) Full details of the flammable liquid, its storage surroundings, handling and location;
b) Most suitable foam concentrate at appropriate concentration;
c) Most suitable solution application rate;
d) Most suitable foam making and delivering equipment;
e) System operating time;
f) Quantity of foam concentrate required for extinction;
g) Most suitable proportioning arrangement;
h) Pipework size and friction losses;
j) Water supply arrangement, quantity and pressure;
k) Detection equipment;
m) Reserve supply for the concentrate;
n) Drainage and bund provisions;
p) Usage of electrical equipment in flammable vapour area near the tankage area; and
q) Manual operation or automatic operation is required.

The decision as to which option (systems those are fixed or semi-fixed; portable/mobile equipment) to use will depend on site specific conditions considering the following:

1) Number of hazards protected and system vulnerability;
2) Manpower available;
3) Speed of deployment; and
4) Access/egress and requirement of the backup equipment.

6.3 Fixed and Semi-Fixed Systems for Exterior Storage Tanks

6.3.1 *General*

6.3.1.1 *Application*

The above systems are suitable for the protection of outdoor vertical atmospheric storage tanks containing flammable and combustible liquids used in conjunction with fixed foam discharge outlets. The design shall always be based on protecting the tank requiring the largest solution flow including supplementary hose streams where provided. As a rule, tanks containing Class III combustible liquids having flash points above 65 °C shall not be protected by foam systems.

6.3.1.2 *Limitations*

It is likely that the foam may fail to seal the surface of the burning liquid as a result of prolonged free burning prior to foam discharge. Hence, it is always necessary to cool the exterior of the tanks, in addition, by a fixed automatic medium water spray system at a minimum density of 3 litre/min/m^2 of the shell surface area for bulk storage tanks storing flammable liquids flashing at 32 °C and below. Such systems are not suitable for discharge into horizontal tanks and also not suitable for pressurized vessel tanks.

6.3.2 *Design Specification for Tanks Containing Liquid Hydrocarbons*

6.3.2.1 *Foam solution delivery rate*

The following specification shall apply:

a) For tanks containing liquid hydrocarbons, the delivery rate of the foam solution shall be at least 5 litre/min/m^2 of liquid surface area of the tank to be protected.
b) The foam solution delivery rate for tanks containing liquid hydrocarbons, polar solvents or those hydrocarbons that are foam destructive in nature, for example, amines, anhydrides, etc, shall be at least 6.5 litre/min/m^2 of liquid surface area of the tank to be protected.

6.3.2.2 *Foam discharge outlets*

The following guidelines shall be adhered to:

a) Discharge outlets shall be attached to the tank at regular intervals on the periphery (depending on the diameter of the tank) of the tank for the protection of flammable liquid contained in a vertical storage tank.

b) Where two or more outlets are required, the outlets shall be equally spaced around the tank periphery and each outlet shall be sized to deliver foam at minimum application rate or higher but approximately same rate at all outlets.

c) All such outlets shall be individually piped and separate valves shall be provided for isolation outside the dyke area.

d) Fixed discharge outlets shall be and so located or connected at the top as to preclude the possibility of overflowing of the tank contents into the foam lines.

e) Fixed foam discharge outlets shall be provided with vapour seal, frangible under low pressure, to prevent entrance of vapours into foam outlets and pipelines.

NOTE — The vapour seal is designed to rupture within 0.7 to 1.75 kg/cm^2 (10 to 25 psi) pressure at inlet flange of foam chamber, as required by relevant standard. The vapour seal will withstand maximum back pressure of 0.07 kg/cm^2 (1.0 psi) or equal to 686 mm of water column for welded storage tank. If the requirement exceeds 0.07 kg/cm^2 (1.0 psi) as in case of nitrogen blanketing system, then this equipment may not be suitable.

f) Fixed foam discharge outlets shall be provided with inspection means to allow maintenance and for inspection and replacement of vapour seals.

g) Fixed discharge outlets shall be securely attached at the top of the shell so that displacement of the roof is not likely to subject them to serious damage.

h) If fixed discharge outlets are provided with orifices plates, then it should be securely fixed to the equipment. Tanks should be provided with foam discharge outlets/vapour seal chambers as indicated below:

up to 20 m	2 outlets
> 20 m and up to 25 m	3 outlets
> 25 m and up to 30 m	4 outlets
> 30 m and up to 35 m	5 outlets
> 35 m and up to 40 m	6 outlets
> 40 m and up to 45 m	8 outlets
> 45 m and up to 50 m	10 outlets

j) Fixed discharge outlets shall be provided with foam discharge outlets as per the following table around the tank:

Tank Diameter m	*Minimum Number of Discharge Outlets*
Up to 24	1
Above 24 and up to 36	2
Above 36 and up to 42	3
Above 42 and up to 48	4
Above 48 and up to 54	5
Above 54 and up to 60	6

NOTES

1 For tanks having diameter above 60 m, at least one extra discharge outlet shall be provided for every additional 450 m^2 surface area of the liquid or part thereof.

2 For tanks above 60 m diameter, sub-surface injection may be alternatively considered to reduce foam travel distance.

6.3.2.3 *Duration of discharge*

The duration of discharge of foam shall be as suggested below:

Type of the Liquid	*Discharge Outlet Type - 2*
Flash point of 32 °C and below or liquids heated above their flash points	55 min
Flash point above 32 °C	30 min
Petroleum crude oil	55 min
Tanks containing liquid hydrocarbons - Class 'C' petroleum	30 min
Tanks containing Class 'A' and Class 'B' petroleum or liquids heated above their flash points	65 min

6.3.3 *Design Specification for Tanks Containing Flammable and Combustible Liquids Requiring Alcohol Resistant Foams*

Water-soluble and certain flammable and combustible liquids and polar solvents that are destructive to non-alcohol-resistant foams shall require the use of alcohol-resistant foams.

6.3.3.1 *Foam solution delivery rate*

The foam solution delivery rate shall be at least 8.1 litre/min/m^2 for the flammable liquids having a boiling point of less than 32 °C for example, isopropyl alcohol, methyl isobutyl ketone, methyl methacrylate monomer, butyl alcohol, methyl isobutyl ketone, etc, and also for mixtures of water miscible liquids in general.

NOTE — Application rate of AR-AFFF varies with different polar solvent therefore manufacturer shall be consulted for application rate for particular polar compound.

6.3.3.2 *Foam discharge outlets*

Tanks shall be provided with approved fixed foam discharge outlets as indicated in **6.3.2.2**.

6.3.3.3 *Duration of discharge*

Minimum discharge time shall be for 55 min with Type II foam discharge outlet.

6.4 Sub-surface Foam Injection Systems

6.4.1 *Design Criteria*

Subsurface foam injection systems shall be permitted for protection of liquid hydrocarbons in vertical fixed-roof atmospheric storage tanks.

These requirements under this clause are applicable to systems used for the protection of fixed roof storage tanks containing low viscosity hydrocarbon liquids, in which foam is injected (through a product line or a special foam line) at the base of the tank and rises to the surface through the liquid in the tank. Subsurface injection of foam generally is not recommended for fuels that have a viscosity greater than 440 centistokes at their minimum anticipated storage temperature. These systems shall not be used for protection of Class IA hydrocarbon liquids or for the protection of alcohols, esters, ketones, aldehydes, anhydrides, or other products requiring the use of alcohol-resistant foams. Foam concentrates and equipment for subsurface injection shall be suitable for the application. Fluoroprotein foam, AFFF, AR-AFFF and FFFP for subsurface injection shall have expansion ratios between 2 : 1 and 4 : 1.

6.4.2 *Foam Application Rates*

Systems shall be designed to deliver not less than the minimum foam solution application rate as specified below:

Type of Liquids	*Density of Application* l/min/m^2
Foam destructive liquids	6.5
Liquids having boiling point below 32 °C and unstable liquids	8.1
All other liquids	5.0

6.4.3 *Foam Discharge Outlets*

The discharge outlet into the tank shall be permitted to be the open end of a foam delivery line or product line. Outlets shall be sized so that foam generator discharge pressure and foam velocity limitations are not exceeded. The foam velocity at the point of discharge into the tank contents shall not exceed 3 m/s for Class IB liquids or 6 m/s for other classes of liquids over a distance of not less than 20 times the diameters from the outlet. For other pipework the foam velocity shall not exceed 9 m/s. Where two or more outlets are required, they shall be located so that the foam travel on the surface cannot exceed 30 m. Where more than one foam injection point is required, these points shall be designed to deliver foam at approximately the same rate and be positioned to distribute foam evenly over the free surface of the fuel in the tank shell, terminating in a central manifold with separate outlets arranged radially.

Foam outlets positioned at the tank shell or inside the tank *via* a manifold shall discharge foam above any water layer present in the tank. This shall be accomplished by having the outlets located at least 300 mm above the highest water level to prevent destruction of the foam. The sizes and lengths of discharge pipe or lines used beyond the foam maker and the anticipated maximum depth of the fuel to be protected shall be such that the back pressure is within the range of pressures under which the device has been tested and approved. Allowance shall be made for the pressure losses due to friction at valves or bends. A typical subsurface injection method is given in Fig. 1.

6.4.4 The number of foam injection points for subsurface application shall be as given below:

Tank Diameter m	*Flash Point* (32 °C and *below*)[1]	*Flash Point* (*above* 32 °C)[2]
Up to 24	1	1
Above 24 and up to 36	2	1
Above 36 and up to 42	3	2
Above 42 and up to 48	4	2
Above 48 and up to 54	5	2
Above 54 and up to 60	6	3

[1] For tanks having diameters above 60 m and flash point below 32 °C, one additional injection outlet shall be provided for each additional area of 45 m^2.

[2] For tanks having diameters above 60 m and flash point above 32 °C, one additional injection outlet shall be provided for each additional area of 700 m^2.

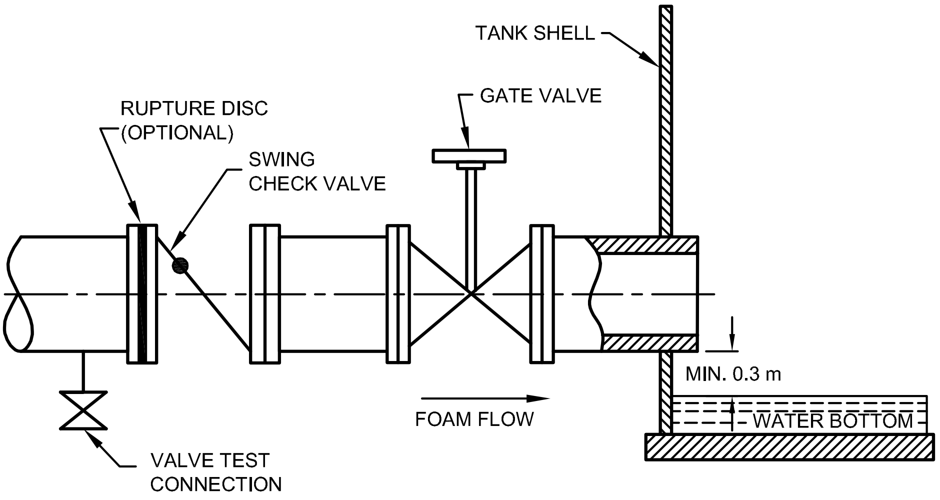


FIG. 1 TYPICAL SUBSURFACE INJECTION

6.4.5 *Duration of Discharge*

The minimum discharge time for low expansion foam at specified application rates shall be as given below:

Risk for Tanks Containing Liquid Hydrocarbons	*Discharge Time min*
Flash point 32 °C and below and for crude petroleum	55
Flash point above 32 °C	30

NOTE — Good judgment should be used in applying foams to tanks containing hot oils, burning bitumen (asphalts), or burning liquids that are heated above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such liquids at a slow rate, it can also cause violent frothing and 'slop-over' of the tank's contents.

6.5 Semi Sub-surface Foam Injection Systems

6.5.1 *General*

These systems are not considered appropriate for floating roof tanks with or without a fixed roof because the floating roof prevents foam distribution. The flexible foam delivery hose is contained initially in a sealed housing and is connected to an external foam generator capable of working against the maximum product head. When operated, the hose is released from its housing, and the hose floats to the surface as a result of the buoyancy of the foam. Foam then discharges through the open end of the hose directly onto the liquid surface. Typical arrangement is shown in Fig. 2.

Consideration should be given to the following factors when selecting this type of system:

a) Total foam output should reach the surface of the burning liquid.
b) With large tanks, the semi-subsurface units can be arranged to produce an even distribution over the fuel surface.
c) Any type of concentrate suitable for gentle surface application to the particular fuel can be used.
d) Foam-generating equipment and operating personnel can be located at a distance from the fire.
e) System can be used for the protection of foam destructive liquids, provided the flexible hose is not affected by them.
f) Certain high-viscosity fuels might not be suitable for protection by this type of system.
g) There is no circulation of the cold fuel and, therefore, no assistance in extinguishment.
h) System can be difficult to check, test, and maintain.
j) High back-pressure foam generator has to produce foam at a pressure sufficient to overcome the head pressure of fuel as well as all friction losses in the foam pipework. Friction losses with foam differ from those with foam solution.

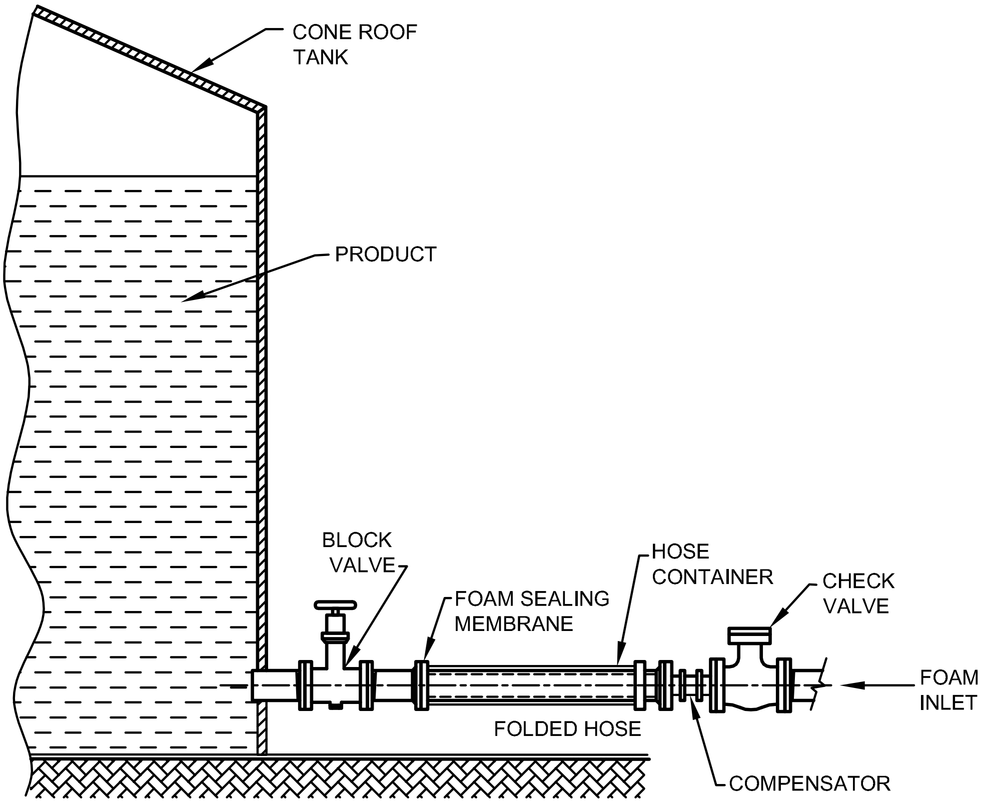


FIG. 2 ARRANGEMENT OF FOAM INJECTION SYSTEM IN SEMI SURFACE

6.5.2 *Application Rates*

Systems shall be designed to deliver not less than the minimum foam solution application rate as specified below:

Type of Liquids	*Density of Application l/min/m²*
Foam destructive liquids	6.5
Liquids having boiling point below 32 °C and unstable liquids	8.1
All other liquids	5.0

6.5.3 *Number of Foam Injection Points for Semi-subsurface Application*

Tank Diameter (in m)	*Number of Discharge Outlets*[1]
Up to 24	1
Above 24 and up to 36	2
Above 36 and up to 42	3
Above 42 and up to 48	4
Above 48 and up to 54	5
Above 54 and up to 60	6

[1] For tanks having diameters above 60 m, one additional injection outlet shall be provided for each additional area of 450 m².

NOTES

1 For liquids having low flash point and low boiling point that is below 32 °C, the required number of foam injection points shall be increased by one.

2 Where more than one foam injection point is required, these points shall be designed to deliver foam at approximately the same rate and be positioned to distribute foam evenly over the free surface of the fuel in the tank shell, away from tank level indicator devices and swing arm product pipes.

3 Semi sub-surface units shall be secured by straps for support and sited within the base of the tank.

4 Non-return valves shall be fitted at the foam entry points adjacent to the tank shell.

5 This system must be laid in conjunction with an approved hydrant system.

6.5.4 *Foam Discharge Outlets*

Various requirements under **6.4.3** are applicable for semi-subsurface application also.

6.5.5 *Duration of Discharge*

The minimum discharge time for low expansion foam at specified application rates shall be as given below:

Risk – Tanks Containing Liquid Hydrocarbons	*Foam and Discharge*	
	Type of Foam	*Discharge Time Through Type II outlet* min
Flash point 32 °C and below	Protein, AFFF, FP, FFFP, Alcohol resistant AFFF or FFFP	55
Flash point above 32 °C	All types	30
Foam destructive liquids	Alcohol resistant	55

6.6 Floating Roof Exterior Storage Tanks

6.6.1 *General*

Normally, fixed outlets are required for open top floating roof tanks. However, when floating roof tanks are covered (fixed cum floating roof tanks), such tanks shall be deemed as fixed roof tanks when floating covers are made of material other than steel for the purpose of protection. If the floating covers are made of steel, such tanks can be construed as open top floating roof type for the purpose of protection. Floating roof tanks have a good fire record and fixed protection is normally contemplated only for the annular rim seal area. Floating roof seals may be of the pantograph type or tube seal type. Foam shall be discharged into the seal area behind a foam dam secured to the floating roof, below the pantograph seal or behind a metal weather shield of tube seal designs (*see* Fig. 3). Adverse wind conditions and obstructions projecting through the fuel surface may reduce the effectiveness of the system and hence suitable allowance is necessary in the rate of foam application. Subsurface and semi-subsurface injection shall not be used for protection of open-top or covered floating roof tanks because of the possibility of improper distribution of foam at the fuel surface. The foam protection facilities for an open-top floating roof tank seal area shall be provided in accordance with **6.6.2**.

6.6.2 Fixed discharge outlets shall be provided for fire protection of seals in open top floating roof tanks for application of foam which shall be achieved in either of the two methods as given below:

a) The first method discharges foam above the mechanical shoe seal, a metal weather shield, or a secondary seal.

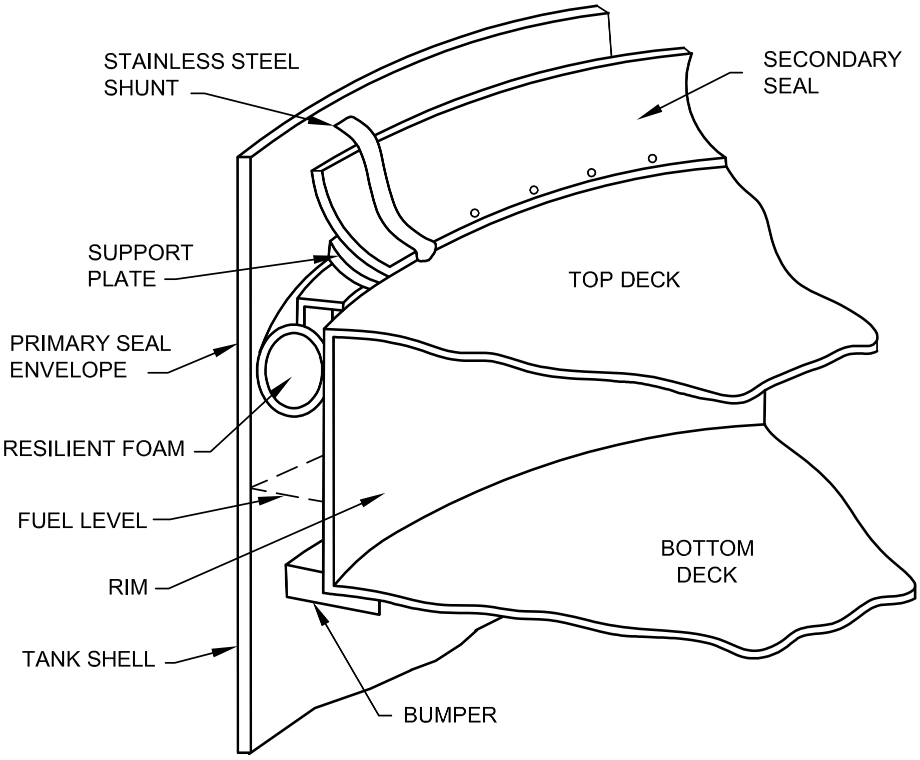


FIG. 3 SEALS IN FLOATING ROOF TANKS (DOUBLE SEAL SYSTEM)

b) The second method discharges foam below a mechanical shoe seal directly onto the flammable liquid, behind a metal weather shield directly onto the tube seal envelope, or beneath a secondary seal onto the primary seal.

6.6.2.1 *Top of seal method with foam dam*

a) Fixed foam discharge outlets located above a mechanical shoe seal, above a tube seal weather shield, or above a secondary seal shall be used in conjunction with a foam dam. There are two methods of application of fixed foam discharge outlets.
    1) Fixed foam discharge outlets (normally Type II) mounted above the top of the tank shell, and
    2) Fixed foam discharge outlets mounted on the periphery of the floating roof.

b) For this application, the fixed foam discharge outlets shall not be fitted with a frangible vapour seal device.

c) The system design shall comprise of the following:
    1) Foam application rates shall be at least 12.2 litre/min/m^2 for various types of seals, such as mechanical shoe seal, tube seal with metal weather shield, fully or partly combustible secondary seal and all metal secondary seal (*see* Fig. 4A to 4D) and duration of foam application shall be at least 20 min.
    2) Foam discharge outlets shall be equally spaced around the periphery of the tank, and shall be designed to deliver foam at approximately equal rates.
    3) The above requirements apply to tanks containing hydrocarbons or flammable and combustible materials requiring alcohol-resistant foams.
    4) Minimum application rates specified above shall apply, unless higher application rates are specified under listings where Type II fixed foam discharge outlets are used. In such cases, duration of foam application may be reduced proportionately subject to a maximum of 25 percent of duration specified in (a) above.
    5) Where the fixed foam discharge outlets are mounted above the top of the tank shell, a foam splashboard is necessary due to the effect of winds.
    6) Maximum spacing between discharge outlets shall be 12 m for dam height between 0.3 m and 0.6 m; and 24 m for height above 0.6 m.

6.6.2.2 *Below the primary seal or weather shield method*

a) Fixed foam discharge outlets located below either a mechanical shoe seal, a metal weather shield, or a metal secondary seal (*see* Fig. 5).

b) Foam discharge outlets shall be equally spaced around the periphery of the tank, and shall be designed to deliver foam at approximately equal rates.

c) The above requirements apply to tanks containing hydrocarbons or flammable and combustible materials requiring alcohol-resistant foams.

d) A foam dam shall be installed where the top of the tube seal is less than 150 mm below the top of the pontoon.

e) Foam application rates shall be at least 20.4 litre/min/m^2 for various types of seals, such as mechanical shoe seal, tube seal with more than 150 mm between top of tube and top of pontoon and tube seal with foam discharge below metal secondary seal and duration of foam application shall be at least 10 min (*see* Fig. 5A, 5B and 5D).

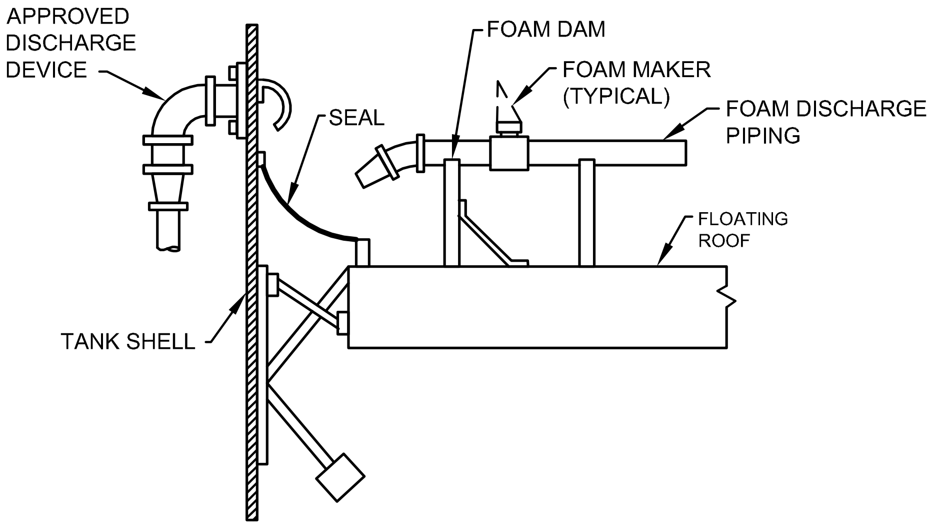
f) Foam application rates shall be at least 20.4 litre/min/m^2 for tube seal with less than 150 mm between top of tube and top of pontoon and duration of foam application shall be at least 10 min. In this case, foam dam shall be provided (*see* Fig. 5C).

g) Minimum application rates specified above shall apply, unless higher application rates are specified under listings where Type II fixed foam discharge outlets are used.

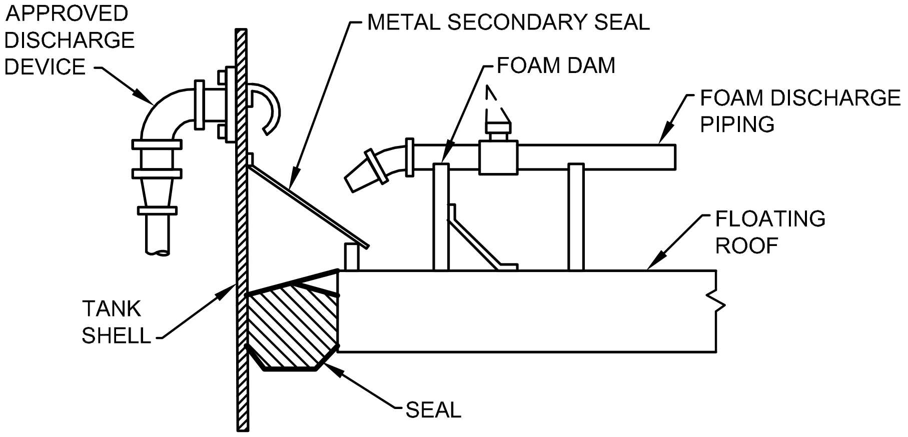
h) Below-the-seal (or shield) application shall not be used with combustible secondary seals.

j) Spacing between discharge outlets shall be as follows:

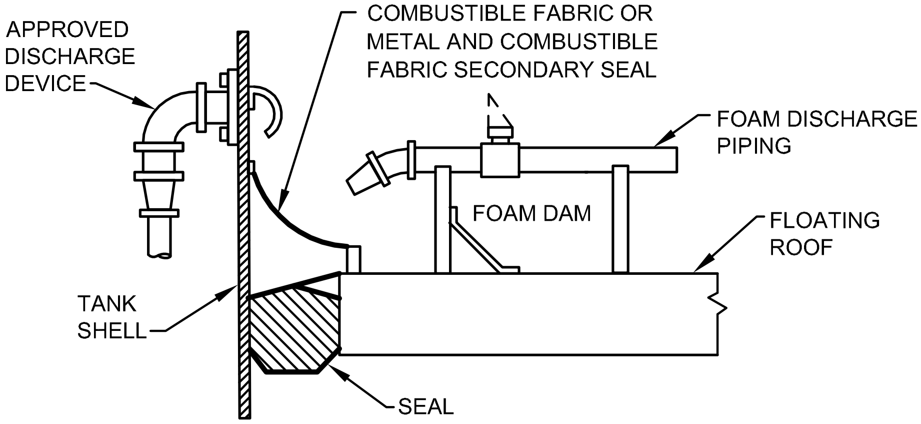
Sl No. (i)	*Type of Seal* (ii)	*Spacing* m (iii)
i)	Mechanical shoe seal type	39
ii)	Tube seal with more than 150 mm between top of tube and top of pontoon	10
iii)	Tube seal with foam discharge below metal secondary seal	10
iv)	Tube seal with less than 150 mm between top of tube and top of pontoon	10



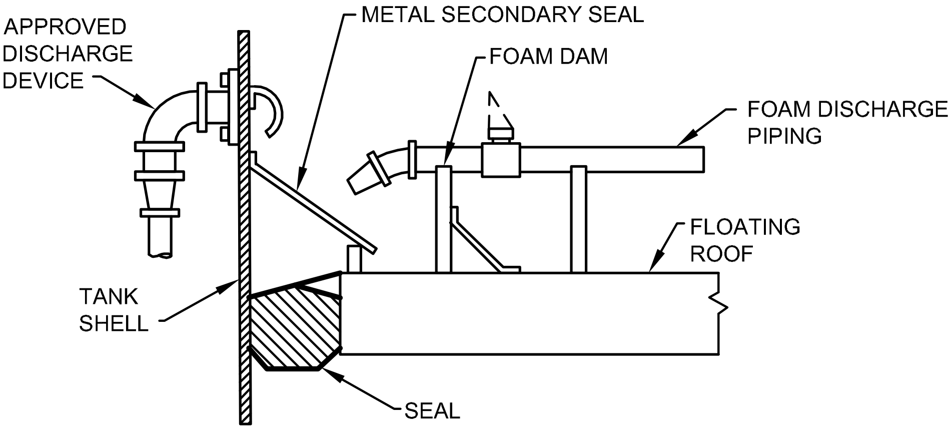
4A FOAM DISCHARGE ABOVE MECHANICAL SHOE SEAL



4B FOAM DISCHARGE ABOVE METAL WEATHER SEAL

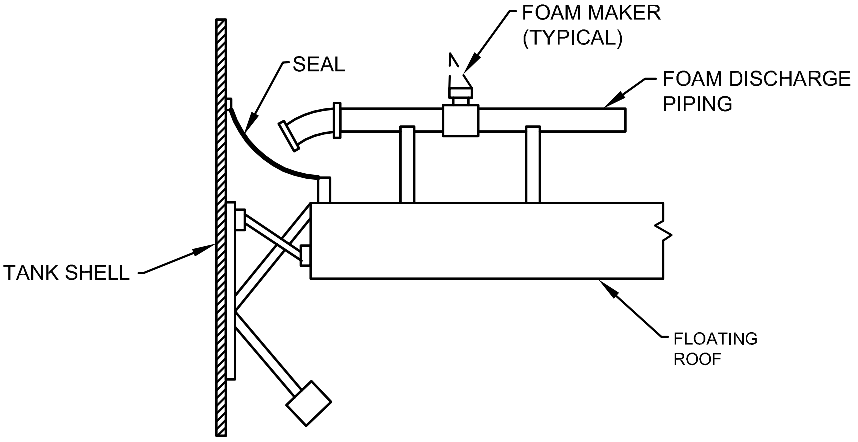

APPROVED DISCHARGE DEVICE
COMBUSTIBLE FABRIC OR METAL AND COMBUSTIBLE FABRIC SECONDARY SEAL
FOAM DISCHARGE PIPING
FOAM DAM
FLOATING ROOF
TANK SHELL
SEAL

4C FOAM DISCHARGE ABOVE SECONDARY COMBUSTIBLE FABRIC SEAL OR METAL WITH COMBUSTIBLE FABRIC SECTIONS.

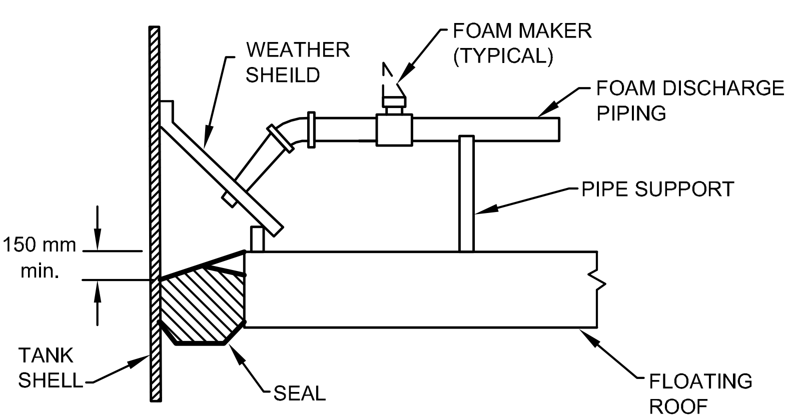


4D FOAM DISCHARGE ABOVE METAL SECONDARY SEAL

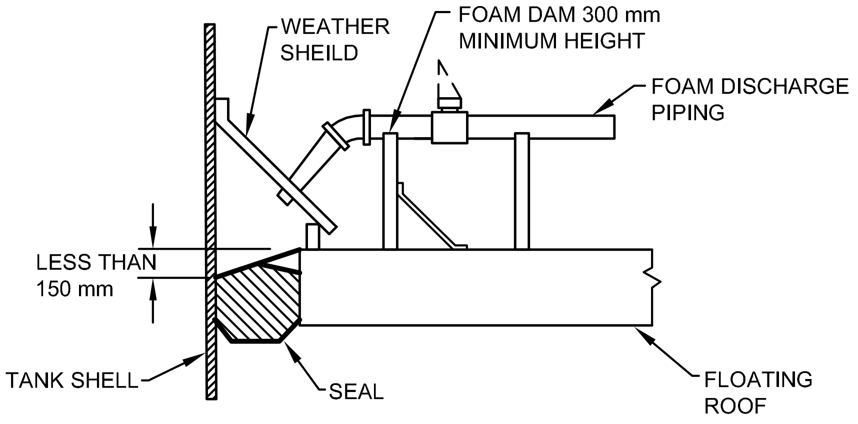
Fig. 4 Top of Seal Application



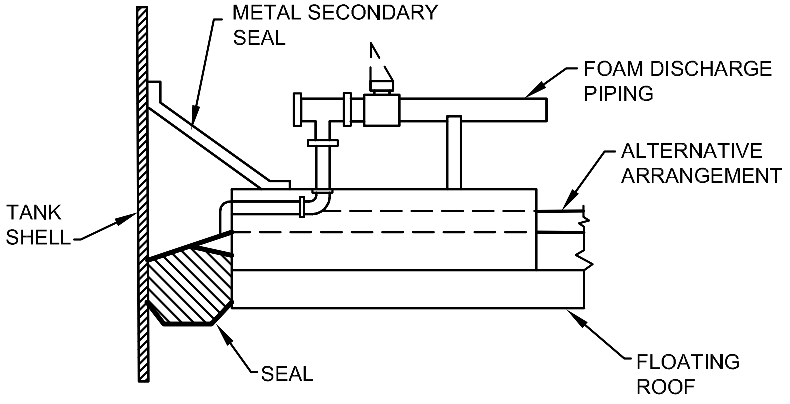
5A FOAM DISCHARGE BELOW MECHANICAL SHOE SEAL - NO FOAM DAM



5B TOP OF SEAL 150 mm OR MORE BELOW TOP OF FLOATING ROOF



5C FOAM DISCHARGE BELOW METAL WEATHER SHEILD
TOP OF SEAL LESS THAN 150 mm BELOW TOP OF FLOATING ROOF



5D FOAM DISCHARGE BELOW METAL SECONDARY SEAL

FIG. 5 BELOW THE SEAL APPLICATION

6.6.2.3 *Foam dam specification*

The following specification shall be followed for foam dams:

a) Foam dam shall be circular and constructed of at least 4 mm steel plate.

b) Foam dam shall be welded or otherwise fastened to the floating roof.

c) Foam dam shall be designed to retain foam at the seal area, at a depth to cover the seal area while causing the foam to flow laterally to the point of seal rupture.

d) Dam height shall be at least 300 mm.

e) Dam shall extend at least 50 mm (*see* Fig. 6) above a metal secondary seal or a combustible secondary seal using a plastic-foam log.

f) Dam height shall be at least 50 mm higher than any burnout panels in metal secondary seals.

g) Foam dam shall be at least 300 mm, but not more than 600 mm from the tank shell.

h) To allow drainage of rainwater, the foam dam bottom shall be suitably slotted on the basis of 275 mm^2 slot area per m^2 of dammed area (0.04 in^2 of slot area ft^2 of dammed area), restricting drain slots to a maximum 9.5 mm in height as shown in Fig. 6.

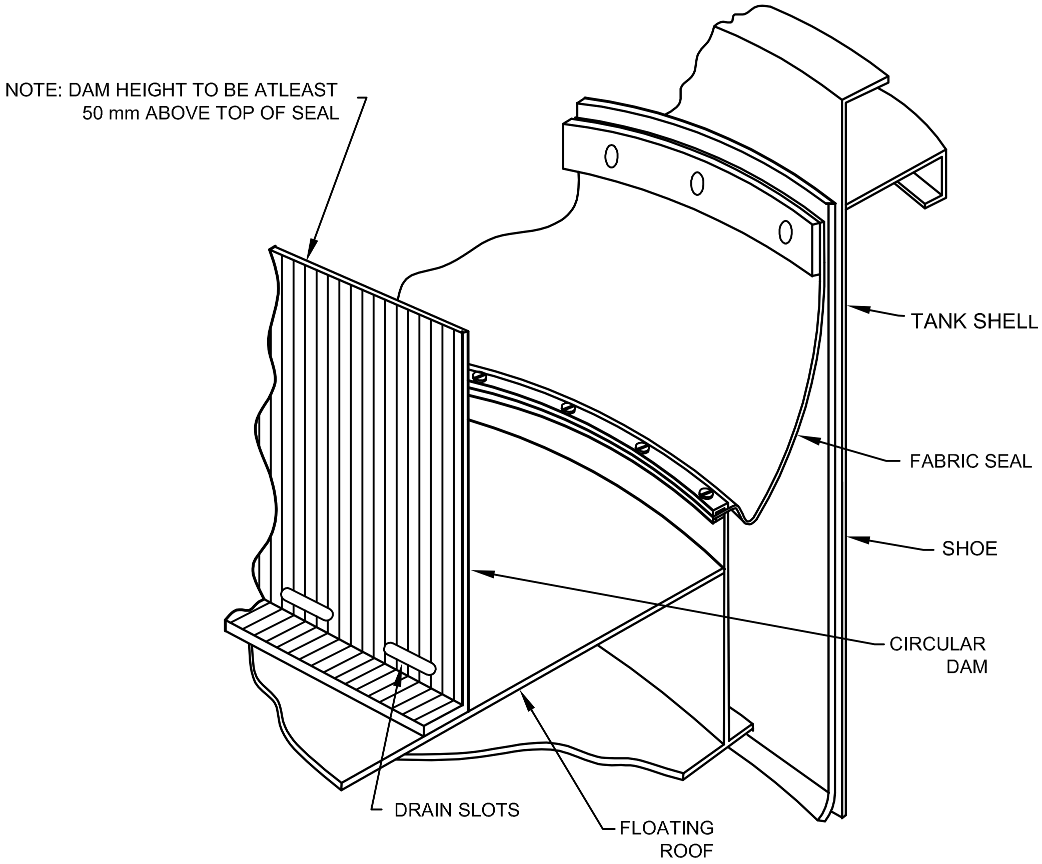


Fig. 6 Seal Area Protection Illustration

6.6.3 *Covered Floating Roof Tanks*

Where the basis for design is a seal fire, the covered (internal) floating roof tank shall be considered as equivalent to an open-top floating roof tank of the same diameter for the purpose of foam system design. For a seal fire, the foam discharge system shall be designed in accordance with the requirements specified in **6.6.2.1**(c) utilizing fixed foam discharge outlets. System design shall be based on protecting the tank requiring the largest solution flow, including supplementary hose streams. Alternatively, if the basis for design is a full surface fire, the covered (internal) floating roof tank shall be treated as equivalent to a fixed-roof (cone) tank of the same diameter for the purpose of foam system design and the system shall be designed in accordance with the requirements specified in **6.3**.

NOTE — Supplementary hose streams shall be available in all cases (*see* **6.3** to **6.6**) shall be provided as called for in IS 13039.

6.7 Foam Monitors and Hand Held Hose Lines Design Criteria

6.7.1 *General*

Monitors/nozzles can be considered as primary protection for bunds and flammable liquid spills. Monitor nozzles shall not be considered as the primary means of protection for fixed-roof tanks over 18 m in diameter except for fighting spill fires. However, they are useful for supplementary protection. Foam handlines shall not be permitted to be used as the primary means of protection for fixed-roof tanks over 9 m in diameter or those over 6 m in height except for fighting spill fires. Monitors shall not be used as the primary means of floating roof seal fire extinguishment because of the difficulty of directing foam into the annular space and the possibility of sinking the roof.

6.7.2 *Foam Application Rates*

To determine actual solution flow requirements, consideration shall be given to potential foam losses from wind, and other related factors. The design parameters for the use of monitors and hand held hose lines to protect tanks containing hydrocarbons shall be in accordance with the Table 1.

Table 1 Application Rates for Foam Monitor and Hand-held Hose Lines

(*Clause* 6.7.2)

Sl No.	Type of Liquids and Hydrocarbons	Minimum Application Rate litre/min/m^2	Minimum Duration of Discharge min
(1)	(2)	(3)	(4)
i)	Flash point between 32 ˚C and 65 °C	6.5	50
ii)	Flash point below 32 °C or liquids heated above flash points	8.1	65
iii)	Crude petroleum	6.5	65

Good judgment should be used in applying foam to tanks containing hot oils, burning asphalts, or burning liquids that have a boiling point above the boiling point of water. Although the comparatively low water content of foams can beneficially cool such fuels at a slow rate, it can also cause violent frothing and 'slop-over' of the tank's contents. Water-soluble and certain flammable and combustible liquids and polar solvents that are destructive to regular (non-alcohol-resistant) foams shall use alcohol-resistant foams. For spill fires of liquids of a depth greater than 25 mm, monitor and foam hose streams shall be limited for use with special alcohol-resistant foams approved, for the purpose. Monitors and hydrants (hand held hose lines) shall be located in the vicinity of the tanks in such a way that the entire surface area of the burning liquid are covered by their throw and shall also comply with the requirements stipulated in IS 13039.

6.7.3 *Tanks within Dyked Areas*

Dyked areas shall be areas bounded by contours of land or physical barriers that retain a fuel to a depth greater than 25 mm. Protection of these areas shall be achieved by fixed or portable monitors, or foam hand held hose lines. The minimum rates of application and duration of discharge shall be 6.5 litre/min/m^2 for a duration of 30 min. Fixed foam discharge outlets shall be sized and located to apply foam uniformly over the dyke area at the application rate specified above. Large dyke areas shall be permitted to be subdivided to keep the total design solution within practical limits. Monitors and hydrants (hand held hose lines) shall be located outside the dyke area. Where the monitor/hand held hose lines discharge is in the form of a compact, high-velocity foam stream, it shall be directed against the dyke walls, tank surfaces, or other structures to prevent its plunging directly into the burning liquid surface. In case of flammable liquids and polar solvents that are destructive to foams shall need to be protected with alcohol-resistant foams at discharge rate of 6.5 litre/min/m^2 for a minimum duration of 30 min.

6.7.4 *Tanks in Non-dyked Spill Areas*

Non-dyked spill areas shall be areas where a flammable or combustible liquid spill might occur, uncontained by curbing, dyke walls, or walls of a room or building. To determine protection for spill fires, the potential spill area shall have to be estimated. Once this area has been determined, following table shall be used to calculate requirements to be used as design criteria for portable nozzles or monitors.

6.8 Fixed Foam Spray Systems

Fixed foam spray systems can be of two types depending upon the type of application namely aspirating type and non-aspirating type.

6.8.1 *Aspirating Type*

This type applies to systems which are designed to discharge foam in the form of a spray, and which are intended to provide primary protection for specific hazards. Foam spray systems are particularly suitable for hazards both outdoors and indoors in which flammable liquid may be spilled, sometimes in large quantities. Typical examples include loading racks, horizontal tanks, pump rooms and dip tanks. Protection of aircraft hangars up to 1 600 m^2 floor area and 7.5 m high may be achieved by systems designed in accordance with the requirements and recommendations of this standard. Larger and/or higher structures may require special consideration over and above than those given in this standard. This relates only to spray discharge of aspirated foam, since some of the sprayers do not produce effective discharge pattern when used with water and AFFF only.

NOTE — Foam nozzles, branch pipes, monitors, etc, that are capable of taking air under venturi effect may be used.

Type of Foam	*Application Rate l/min/m^2*	*Duration of Discharge min*	*Anticipated Spill*
Protein, fluoroprotein	6.5	15	Hydrocarbon
AFFF, FFFP and alcohol resistant AFFF, FFFP	5	15	Hydrocarbon
Alcohol resistant foams	6.5	15	Flammable/combustible liquids requiring such foams

6.8.2 *Non-aspirating Type*

This covers systems which are designed to produce, discharge or distribute foam solution in the form of a series of fixed sprayer. Such systems may be used on either indoor or outdoor risks in which water sprays alone could be marginally effective, but where the addition of AFFF foam concentrate would improve the extinguishing performance.

NOTE — These are not capable of taking air under venturi effect.

6.8.3 *Discharge Devices*

Discharge devices for foam-water deluge and spray shall be permitted to be air-aspirating, such as foam-water sprinkler and foam-water spray nozzles, or they shall be permitted to be non-air-aspirating, such as standard sprinklers.

6.8.4 *System Design and Installation*

6.8.4.1 The following discharge parameters shall be taken into consideration:

a) Design discharge density shall be in accordance with the applicable occupancy standard for water or foam-water systems but in no case less than 6.5 litre/min/m^2.
b) Water-soluble and certain flammable and combustible liquids and polar solvents that are destructive to conventional foams necessitate the use of alcohol-resistant foams.
c) In all cases, the manufacturer of the foam concentrate and the foam-making equipment shall be consulted regarding limitations and for recommendations based on listings or specific fire tests.

6.8.4.2 The discharge duration shall confirm to the following:

a) Foam solution shall be designed to discharge for a period of 10 min (based on the density as specified in **6.8.4.1**) over the entire system area for deluge and spray foam-water systems and over the design area for wet pipe, dry pipe, and preaction foam-water systems.
b) Where actual system discharge exceeds the minimum as specified in **6.8.4.1** a proportionate reduction in the duration of foam discharge time shall be permitted, but in no case the duration shall be less than 7 min.

6.8.4.3 The proportioning system selected shall be capable such that, actual calculated system discharge demand at the proper foam percent for the most hydraulically demanding condition and the, actual calculated system discharge demand at the proper foam percent for the least hydraulically demanding condition. Also, the foam liquid pressures shall be at least equal to the highest anticipated water pressure.

6.8.4.4 Where foam concentrate pipelines to the protective system injection points are run underground or where they run above ground for more than 15 m, these lines shall be maintained full, and a means of checking the tightness of the system shall be provided. The temperature of the foam concentrate lines and components shall be maintained within the storage temperature limits specified for the foam concentrate.

6.8.4.5 Drainage facilities shall be provided for the safe removal or retention of the largest anticipated flammable liquid spill including free water reaching the floor from fixed fire protection system, as well as discharge from hose streams.

6.8.5 *Foam Water Sprinkler Systems (Wet, Dry and Pre-action Systems)*

The total design area shall be 450 m^2 where applicable occupancy standards specify design areas different from that specified in, the occupancy standards shall take precedence.

The coverage area of sprinkler shall not exceed 9 m^2 per sprinkler and spacing shall not exceed 3.7 m between sprinklers on a branch line or between branch lines. Where applicable occupancy standards, such as IS 15105 specify sprinkler spacing different from that specified above, the occupancy standards shall take precedence.

The temperature rating of sprinklers shall be within the range of 121 °C to 149 °C where they are located at the roof or ceiling. Where sprinklers are located at an intermediate level, the temperature rating shall be within the range of 57 °C to 79 °C unless ambient conditions require a higher rating.

In automatic systems, the detection equipment shall be connected to a means for tripping water deluge valves and other system-control equipment. Supplemental manual means for this purpose shall also be provided.

In automatic systems, foam concentrate injection shall be activated automatically by, or concurrently with, activation of the main water supply control valve. Manual operating means shall be designed for this purpose. Automatic detection equipment, whether pneumatic, hydraulic, or electric, shall be provided with complete supervision arranged so that failure of equipment, loss of supervising air pressure, or loss of electric energy results in clear notification of the abnormal condition. Where used in a corrosive atmosphere, the detection devices shall be of material(s) to resist corrosion. Automatic detection equipment of the electric type and any auxiliary equipment of the electric type, if in hazardous areas, shall be designed specifically for use in such areas. In automatic systems, manually operated tripping devices shall actuate the automatic control valve by mechanical, pneumatic, electric, or other approved means. The manual device shall be strong enough to prevent breakage. Manual controls shall not necessitate a pull of more than 178 N (force or a movement of more than 350 mm to secure operation).

6.9 *See* Annex C for details on various methods for foam injection and foam concentrate proportioning systems.

6.10 System Hydraulics

System piping shall be hydraulically designed to obtain reasonably uniform foam and water distribution and to allow for loss of head in water supply piping. The adjustment in pipe sizes shall be based on a maximum variation of 20 percent above the specified discharge rate per sprinkler or nozzle. Pipe sizes shall be adjusted according to detailed friction-loss calculations. These calculations shall show the relationship between the water supply and the water demand. Hydraulic calculations for determining the foam solution and water flow characteristics of systems covered by this standard shall be in accordance with IS 15105 or IS 15325 as the case may be. Piping carrying foam solution shall be sized as if carrying plain water.

7 MEDIUM AND HIGH-EXPANSION SYSTEMS

See IS 12835 (Part 2).

8 FOAM SYSTEM PIPING

8.1 Piping Network

8.1.1 Pipe work shall be metallic (corrosion resistant) compatible with concentration or pre-mixed solution being used. Dry foam system pipe network may be galvanized provided it is well washed thoroughly after every use. Wet foam pipe-work should not be galvanized as this may adversely affect the foam concentrate or pre-mix solution. Corrosion resistant materials, such as stainless steel may instead be used, or the pipe-work may be protected with a suitable coating. Pipe shall be of steel or other alloy suitable for the pressure and temperature involved. Joints shall be welded, flanged or screwed with a taper thread. Where gaskets are required they shall be fabricated from a material which is non-combustible when tested in accordance with IS/ISO 834 (Part 1). Foam concentrates have a lower surface tension than water, and they may cause internal pipe scale or sediment to loosen, with the risk of blockage of sprayers, proportioning equipment, etc. Pipes and fittings shall be carefully cleaned before assembly, and any loose jointing material shall be removed. All pipework inside bund areas and within 15 m of non-bunded tanks shall normally be buried under at least 0.3 m depth of earth, but may be permitted above ground if properly supported and protected against mechanical damage. All pipework within the bund area or within 15 m of the tank to be protected shall be designed to withstand the upward shock due to a tank roof rupture. When pipework is buried, a metal flexible joint shall be provided at the base of each tank riser. The flexible joint shall consist of a system of suitable standard weight fittings made from steel, or ductile, or malleable iron. When pipework is supported above ground, it shall have the necessary upward and lateral support but shall not be held down within a distance of 15 m from the tank shell, so as to permit sufficient flexibility in an upward direction to obviate the need for a flexible joint. If threaded connections are used within this distance, they shall be back welded for strength. When tank risers are of 100 mm diameter or larger, they shall be welded to the tank by means of steel brace plates positioned perpendicular to the tank, and centered on the riser pipe. One brace shall be provided at each shell course. The design may be used instead of swing joints, or unconstrained pipework as described above. One flanged or union joint shall be provided in each riser within 15 m of the ground to permit hydrostatic testing of the pipework system up to this joint.

NOTE — With all welded construction, this may be the only joint that can be opened.

8.1.2 In systems with semi-fixed equipment on fixed roof tanks, the foam or solution laterals to each vapour seal shall terminate in a connection which is outside the bund walls and at least 15 m from tanks of 15 m diameter or less, and one tank diameter from the shell of larger tanks. The inlet to the pipework shall be fitted with corrosion resistant metal connections provided with plugs or caps. Piping design shall be such that at the required rate of flow through the foam system pipelines, pressure at the foam inductor is adequate to give a minimum running pressure of 3.5 kg/cm^2 at the foam pourers after taking into account losses like frictional loss, static loss, and loss across the inductor. Foam velocity in the pipelines under the above circumstances shall not exceed 3 m/s. All pipes and fittings and also their run and supports shall confirm to the relevant Indian standards.

8.2 Drainage

All dry piping shall be arranged to drain and shall have a minimum pitch towards the drain of 1 in 120. Drain valves shall be provided for premix or finished foam lines at low points in piping, whether below or above ground.

8.3 Valves

The laterals to each foam vapour seal box on fixed roof tanks shall be equipped with separate valves, which shall be outside the bund in fixed installations. Control valves to divert the foam or solution to the appropriate tank may be either in a central control house, or at points where lateral to the protected tanks branch from a main feed line. Control valves shall be located outside bunds and shall be not less than the following distances from the shell of the tank which they serve:

a) 15 m for tanks less than 15 m in diameter; for tanks 15 m in diameter or larger, except that control valves may be permitted at less than the above distances where they are adequately protected against fire.
b) Where two or more foam proportioners of foam generators are installed in parallel discharging into the same outlet header, valves shall be provided between the outlet of each device and the header.
c) Water line to each foam proportioner or foam generator inlet shall be equipped with a separate valves.

Cutoff valves shall conform to IS 14846 for PN 1.0 and Class 2. In case of systems having working pressure in excess of 7 kg/cm^2, P.N. 1.6 and Class 3, rating would be necessary for valves conforming to IS 14846. Cast steel valves of class 150 are however acceptable irrespective of the working pressure of the system. Other types of valves like rising spindle valves may be used, subject to compliance with relevant Indian standards. Butterfly valves also can be accepted subject to the condition that the valves of diameter exceeding 150 mm shall necessarily be gear operated.

8.4 Pipe Fittings

Fittings installed underground shall be of cast iron 'heavy' grade conforming to IS 1538 whereas those installed above ground shall normally be of 'medium' grade wrought steel or mild steel conforming to IS 1239 (Part 2) or malleable iron fittings conforming to IS 1879.

8.5 Pipe Jointing

Pipe threading shall be in conformance with IS 554. Precautions shall be taken to ensure that the openings are fully cut out and that no obstructions remain in the waterway. Cast-iron fittings shall not be used where dry sections of piping are exposed to possible fire or where fittings are subject to stress in self-supporting systems. Rubber or elastomeric-gasketed fittings shall not be used in fire-exposed areas unless the foam system is automatically actuated. Fittings carrying foam concentrate shall not be galvanized.

8.6 Flushing Requirements

Provision shall be made for flushing with clean water any line that is normally empty but which have contained foam concentrate, premix solution or foam after use or test of the system. Water supply mains, both underground and above ground, shall be flushed thoroughly at the maximum practicable rate of flow, before connection is made to system piping, in order to remove foreign materials which may have entered during installation. The minimum rate of flow for flushing shall be not less than the water demand rate of the system, as determined by the system design and available water supply. The flow shall be continued for a sufficient time to ensure thorough cleaning. Flushing water shall be disposed outside the system. All foam system piping shall be flushed after installation, using its normal water supply with foam forming materials shut off, unless the hazard cannot be subjected to water flow. Where flushing cannot be accomplished, pipe interiors shall be carefully examined for cleanliness during installation. Pipework scale traps shall be provided in the line upstream of foam making equipment. Strainers shall be inspected and cleaned after each use. Tanks and pipes which are normally filled with liquid shall be protected against freezing where appropriate.

8.7 Strainer

A strainer shall be fitted where a 9.5 mm diameter sphere will not pass through the waterways. Strainers shall be provided where solids of size large enough to obstruct openings or damage equipment are present. The ratio of the strainer's open basket area to its inlet pipe area shall be at least 10 : 1. The net open area of the strainer shall be at least four times the area of the suction piping.

8.8 Detection System

The fire alarm and detection system shall comply with various provisions of IS 2189 and IS 15908. Automatic detection equipment, whether pneumatic, hydraulic or electric shall be provided with supervision so arranged that failure of equipment or loss of supervising air pressure or loss of electric energy will result in positive notification of the abnormal condition. The detection system shall activate a local alarm as well as an alarm at a constantly attended location. These shall also be actuated when the system is operated manually. In some special cases, it may be desirable to arrange the system to shut off automatically after a predetermined operating time. This feature shall be subject to approval of the authority having jurisdiction. Electric automatic detection equipment and any auxiliary electric equipment, if in hazardous areas, shall be expressly designed for use in such areas. Various types of approved flammable gas or fire detection devices may be used. These detectors usually activate the system by operating the water control valve or other actuating device. All other equipment shall be so interconnected that it is also activated so that properly mixed foam solution is supplied to the foam makers and foam distributed over the hazard. Small systems for localized hazard may be unsupervised subject to approval of authority having jurisdiction. As regards usage of special detectors, arrangements like LSHS cables and flame detection systems, attention is drawn to IS 2189. All operating devices shall be suitable for the service conditions they will encounter. They shall neither be readily rendered inoperative, nor be susceptible in inadvertent operation, by environmental factors, such as high or low temperature, atmospheric humidity or pollution or marine conditions.

All automatically actuated fixed foam system shall have pressure switches installed in the downstream of discharge line of foam piping system.

For special requirements to cater to peculiar situations specialist literature may be made but full details with necessary inputs from these standards shall be made available prior to installation.

NOTE — Special literature, such as NFPA 72, BS 5839, EN-13565-2, may also be referred.

9 FOAM PROPORTIONING SYSTEMS

See Annex D for details on various methods for foam injection and foam concentrate proportioning systems.

10 COMMISSIONING AND PERFORMANCE TESTS

10.1 General

The complete system should be inspected and tested to determine that it is properly installed, and that it will function as designed. A commissioning test programme should be submitted by the installer.

10.2 Inspection

A visual inspection should be conducted to ensure that the system has been installed correctly. Inspection should include conformity with design drawings and specifications, continuity of pipework, checking, removal of temporary blinds, accessibility of valves, control and gauges, and proper installation of foam-makers, vapour seals, and proportioning devices. All equipment should be checked for correct identification and operating instructions.

10.3 Pressure Tests

All pipework, except that handling expanded foam for other than base injection application, should be subjected to a hydrostatic pressure test at 14 bar or 1.5 times the maximum pressure anticipated, whichever is the greater for a period of 2 h. All normally dry horizontal pipework should be inspected for drainage.

10.4 Component Inspections

All operating devices and equipment should be inspected for proper functioning and a record should be made to indicate that the required performance will be met.

10.5 Discharge Tests

Whenever possible, flow and distribution tests should be conducted to ensure that the hazard is fully protected in conformity with the design specification; and to determine the running pressure, actual discharge rate, consumption rate of foam concentrate, man power requirements and other operating characteristics. Wherever possible the foam discharged should be inspected and preferably tested to ensure that it is satisfactory for the intended purpose performance.

10.6 System Restoration

After completion of the performance tests, the system should be flushed and restored to operational condition.

10.7 Periodic Inspection, Testing and Maintenance

The performance of all foam equipment and foam systems under emergency conditions is best ensured by periodic test and the owner of the installation has the total responsibility for ensuring that the system is in good working order at all times. The responsibility is in no way diminished by any periodic or regular servicing carried out by the installer or his agent. The continued effective performance of foam equipment depends on fully adequate maintenance procedures, with periodic testing where possible. The many variations in system design and equipment application for hazards requiring form, make it impossible to establish anything other than general procedures for periodic inspection.

Each foam system should have its own servicing/maintenance check list which should be available to the owner when system is commissioned. Weekly visual programme of inspection to ensure that there are no leaks, and that there is no damage to pipework or foam-making units shall be carried out. All operating controls must be seen to be properly set, and all components are undamaged. It is recommended that every foam system should be serviced at least annually and this can be achieved by an inspection. If there are any associated electrical detection and alarm system, these should be serviced four times a year. A record confirming compliance should be maintained.

10.8 Inspection Programme

The following inspection programme is suggested:

The owner should carry out a weekly visual programme of inspection to ensure that:

a) there are no leaks;
b) there is no damage to pipework or foam-making units;
c) all operating controls and components are properly set and undamaged; and
d) the water supply is available and at the right pressure.

10.8.1 Monthly inspection involves that of all operators that are familiar with the equipment or system and that new employees have been instructed about its use.

10.8.2 Quarterly inspection involve those relating to electrical detection and outdoor systems and that they are serviced by the nominated servicing organization and that an inspection report has been received.

10.8.3 Half yearly inspection/service involve confirmation that a full foam firefighting system (mechanical) has been carried out and that a confirmatory report to this effect has been received.

10.8.4 Annual inspection involve ensuing that a foam concentrate or foam solution test report has been received.

10.9 Servicing Schedule

The following servicing schedules are suggested.

10.9.1 All electrical detection and alarm systems should be thoroughly tested and serviced, quarterly.

10.9.2 The following is the schedule suggested half-yearly:

a) *Foam producing equipment* — Proportioning devices, their accessory equipment and foam-makers should be inspected for mechanical damage, corrosion, blockage of air inlets and correct manual function of all valves. This may necessitate temporary isolation of the water main.

b) *Pipe work* — Above ground pipework should be examined to determine its condition and that proper drainage is maintained. Pressure tests of normally dry pipework should be made when visual inspection indicates questionable strength due to corrosion or mechanical damage. Underground pipework should be spot checked for deterioration at least every 5 years.

c) *Strainers* — Strainers should be inspected and cleaned. This should always be accomplished after any flow test.

d) *Valves* — All control valves should be checked for correct manual function and automatic valves should in addition be functionally checked automatically. This may necessitate the temporary isolation of water or other liquid supply. A visual inspection should be made of foam concentrate and premix solution tanks and storage containers for evidence of deterioration.

10.9.3 In addition to the normal 6 monthly inspection, annual servicing of foam concentrate or solution sample testing shall be carried out. All foam concentrates or solutions should be carefully analyzed for changes in constitution and characteristics. Their storage in shipping containers and in storage tanks should be carried out according to the manufacturer’s recommendations. Exposure to extreme heat, cold, contamination, or mixing with other materials should be avoided. Sedimentation or precipitate formation in containers or tanks of concentrate should be carefully checked.

11 REQUIREMENTS REGARDING SUBMISSION OF PLANS

11.1 Plans for submission shall be drawn up in accordance with the following requirements:

a) Plans shall be clear, contain all required details including scale and point of compass, and shall be dated.

b) Plans of new installation shall show the entire compound, all buildings therein, with their door and window openings, and the boundary walls. Buildings under construction and future extension envisaged, shall be indicated by the dotted lines. Plans of extensions to approved existing installations need not show the rest of the compound but sufficient details shall be given of the existing installations in correlation to the extension, to enable the Authorities’ inspection staff to check the plans and offer comments. In case of storied buildings, drawings submitted shall include plans of each storey together with sectional elevations.

c) Material plans shall be on white paper or ammonia paper or ferro prussiate paper.

d) Plans shall generally be prepared in accordance with SP 46, shall not exceed 850 mm × 1 200 mm in size and shall be drawn to a scale of 1 : 500 or 1 : 1 000. In the case of very large compounds with more than one risk, it is advisable to submit separate plans for each risk with a key plan showing the relative situation of the various risks, etc in the compound.

11.2 Detailing

11.2.1 The drawings shall include and accompanied by the following information:

a) Physical details of the hazard, including the location, arrangement, and hazardous materials involved;

b) Type and percent of foam concentrate;

c) Required solution application rate or submergence volume calculations;

d) Water requirements;

e) Calculations specifying required amount of foam concentrate;

f) Hydraulic calculations;

g) Identification and capacity of all equipment and devices;

h) Location, routing and supporting details of piping, detection devices, operating devices, foam generators, discharge outlets, and auxiliary equipment;

j) Complete details of the tanks being protected, wind girders, location of foam pourers, valves, foam monitors, hydrant outlets in the vicinity, etc;

k) Schematic wiring diagram; and

m) Explanation of any special features.

11.2.2 Complete plans and detailed data describing pumps, drivers, controllers, power supply, fittings, suction and discharge connections, and suction conditions shall be submitted for approval before installation.

11.2.3 Where field conditions necessitate any significant change from the approved plan, revised ‘as constructed’ plans shall be supplied for approval.

11.2.4 Charts that specify head, delivery, efficiency, and brake horsepower curves of pumps shall be furnished.

11.3 Water Supply

The drawings shall show water supplies and pipework therefrom up to the installation control valves. The drawings shall be on an indicated scale of not less than 1 : 100. A key to the symbols shall be included. The position and type of stop and check valves and any pressure reducing valve, water meter, water lock, orifice plate and any connection supplying water for other services shall be indicated.

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
554 : 1999	Pipe threads where pressure-tight joints are made on the threads — Dimensions, tolerances and designation (*fourth revision*)
IS/ISO 834-1 : 1999	Fire resistance tests — Elements of building construction: Part 1 General requirements
1239 (Part 2 : 2011)	Steel tubes, tubulars and other steel fittings: Part 2 Steel pipe fittings (*fifth revision*)
1538 : 1993	Cast iron fittings for pressure pipes for water, gas and sewage (*third revision*)
1879 : 2010	Malleable cast iron pipe fittings — Specification (*third revision*)
2189 : 2008	Code of practice for selection, installation and maintenance of automatic fire detection and alarm system (*fourth revision*)
4989 : 2018	Foam concentrate for producing mechanical foam for firefighting — Specification (*fourth revision*)
7673 : 2004	Glossary of terms for firefighting equipment (*first revision*)
8757 : 1999	Glossary of terms associated with fire safety (*first revision*)
13039 : 2014	Code of practice for external hydrant systems provision and maintenance (*first revision*)
14846 : 2000	Sluice valves for water works purposes (50 to 1200 mm) — Specification
15105 : 2021	Design and installation of fixed automatic sprinkler fire extinguishing systems — Code of practice (*first revision*)
15325 : 2020	Code of practice for design and installation of fixed automatic high and medium velocity water spray system (*first revision*)
15908 : 2021	Selection, installation and maintenance of control and indicating equipment for fire detection and alarm system — Code of practice (*first revision*)
SP 46 : 2003	Engineering drawing practice for schools and colleges (*first revision*)

ANNEX B

(*Clause* 5.1.5)

GENERAL INFORMATION OF FOAM PROTECTION SYSTEMS

B-1 GENERAL

Fixed fire protection employing foam can be achieved by different types of application depending upon the nature and type of the risks to be protected. Merits and de-merits of each system are listed hereunder:

B-2 FIXED AND SEMI-FIXED SYSTEMS

B-2.1 Possible merits and demerits of the systems are as listed below:

a) The total foam output may be applied to fuel surface.
b) An even foam distribution may be achieved.
c) The system comprises simple equipment capable of withstanding fire exposure.
d) Only moderate maintenance of the foam-making vapour seal box and pouring equipment is required.

The above systems are suitable for the protection of outdoor vertical atmospheric storage tanks containing flammable and combustible liquids used in conjunction with fixed foam discharge outlets. The design shall always be based on protecting the tank requiring the largest solution flow including supplementary hose streams where provided.

It is quite possible that the equipment attached to the tanks can be damaged by exposure or explosion from within or from the surroundings.

It is likely that the foam may fail to seal the surface of the burning liquid as a result of prolonged free burning prior to foam discharge. Hence, it is always necessary to cool the exterior of the tanks, in addition, by a fixed automatic medium water spray system at a density of 3 litre/min/m^2 of the shell surface area for bulk storage tanks storing flammable liquids flashing at 32 °C and below.

B-3 SUB-SURFACE FOAM SYSTEMS

B-3.1 These systems possess following advantages:

a) Total foam output reaches the tank.
b) With large tanks, suitably arranged inlets allow even foam distribution over the whole free surface area of the fuel.
c) System is essentially simple and, being at ground level, is less likely to be damaged by fire or explosion.
d) Circulation of cold fuel from the base of the tank to the burning surface caused by the rising foam stream can be utilized to assist extinction and to dissipate hot fuel layers at the burning surface.
e) Essential equipment and operating personnel may be located at safe distance from the fire.
f) It may be possible to use the normal product line for foam injection.
g) System is easy to check and maintain.

B-3.2 There are certain limitations associated with the subsurface foam systems as indicated below:

a) Sub-surface systems are not suitable for water-miscible fuels.
b) Sub-surface systems are not suitable for the protection of floating roof tanks because the roof will prevent complete foam distribution.
c) Only foams which will tolerate severe mixing with fuel are suitable for subsurface application into a wide range of tanks of various heights and diameters.
d) The foam needs to be injected above any water in the base of the storage tank, in order to prevent the foam being destroyed.
e) Sub-surface systems may not be suitable for certain high viscosity fuels.
f) Only fluoroprotein, AFFF and AR-AFFF type foams are suitable for this application.

B-4 SEMI SUB-SURFACE FOAM SYSTEMS

B-4.1 These systems possess the following advantages:

a) The total foam output reaches the surface of the burning liquid.
b) With large tanks, the semi sub-surface units can be arranged to produce an even distribution over the fuel surface.
c) Protein, fluoroprotein or AFFF or AR-AFFF concentrates may be used.
d) Suitable for light fuels like gasoline and kerosene.
e) Foam generating equipment and operating personnel may be located at a safe distance from the fire.
f) Any type of foam is suitable for gentle application to the particular fuel.

B-4.2 The following limitations are associated with these systems:

a) Semi sub-surface systems may not be suitable for the protection of floating roof tanks, because the roof will prevent distribution.
b) Certain high viscosity fuels may not be protected by this system.
c) Circulation of the cold fuel which could assist extinction is not induced.
d) The system may be difficult to check, test and maintain. The hose container need replacement at regular intervals.
e) Not at all suitable for water miscible fuels.
f) The foam generator has to produce foam at a pressure sufficient to overcome the high back pressure of the head of fuel as well as frictional losses in the foam pipework. Frictional losses with foam differ from those with foam solution.

B-5 FIXED FOAM POURERS FOR OPEN TOP FLOATING ROOF TANKS

B-5.1 These systems possess following advantages:

a) Total foam output reaches the rim seal area.
b) Using foam pourers and a foam dam, the equipment is simple and requires only moderate maintenance.
c) Foam is applied gently without severe mixing with the fuel.

B-5.2 The following limitations are associated with these systems:

a) Where foam is injected below the pantograph or weather shield a foam generator might not be capable of operating against the pressure required to force foam around the rim seal area.

b) Where foam is injected into the rim seal area, special pipework is needed to conduct foam from outside the shell onto the roof area. This needs to be hinged or jointed to allow for movement of the roof, and has to be protected or designed to withstand the effects of a rim seal fire.

c) Adverse winds and obstructions projecting through the fuel surface may reduce the effectiveness of the system and allowance should be made in the rate of application of foam.

B-6 FIXED FOAM SPRAY SYSTEMS (ASPIRATING TYPE)

B-6.1 These systems possess the following advantages:

a) Foam can be distributed evenly over the fuel surface producing rapid fire control.

b) Hot surfaces in contact with the fuel can often be more effectively cooled by a spray discharge. Exposures may also be protected from heat radiation by the foam spray discharge.

c) Equipment may be readily designed for automatic operation.

d) While low expansion foam is not considered an effective agent for extinguishing three dimensional running flammable liquid fires, it can control the pool fire beneath the running fire, leaving control of the running fire to other means like dry powder fire extinguishers.

e) With some flammable liquids the water spray distributed by foam sprayers can provide effective fire control as in high flash point hydrocarbons.

B-6.2 The following limitations are associated with these systems:

a) Foam discharge might be carried by the wind beyond the area of the fuel spill.

b) Foam sprayers might have small passages susceptible to blockage.

c) Fixed foam sprays applied horizontally might be obstructed by equipment positioned temporarily in the direction of discharge.

d) Pipework for overhead spray nozzles might obstruct normal operations. The load they impose on the roof structure should be carefully calculated to avoid overloading.

e) Overhead application might need supplementary low level application in order to provide coverage below large obstructions as in beneath aircraft in hangars.

f) Above ground pipework might be susceptible to damage by explosion. Pipework should therefore be positioned or protected to avoid this possibility.

g) These systems are not suitable for use on water soluble liquids exceeding 25 mm in depth unless AR-AFFF type of foam is used.

B-7 FIXED FOAM SPRAY SYSTEMS (NON-ASPIRATING TYPE)

B-7.1 These systems possess following advantages:

a) Spray can be distributed evenly over the fuel surface producing rapid fire control.

b) Hot surfaces in contact with the fuel can often be more readily cooled by the spray discharge than by a foam blanket. Exposure may also be protected from heat radiation by the non-aspirated spray discharge.

c) Equipment is readily designed to be automatic.

d) While non-aspirated foam is not considered an effective agent for extinguishing three dimensional running flammable liquid fires, it can control the pool fire underneath the running fire, thus permitting fire control by other means.

e) With some flammable liquids the water spray distributed by non-aspirated nozzles can provide effective fire control in the absence of foam solution.

f) Ground level ‘pop-up’ non-aspirated nozzles deliver solution at the seat of the fire.

B-7.2 The following limitations are associated with these systems:

a) Non-aspirated foam discharge might be carried by the wind beyond the area of the fuel spill.

b) Non-aspirated foam sprayers have small passages susceptible to blockage.

c) Fixed non-aspirated foam sprays applied horizontally might be obstructed by equipment positioned temporarily.

d) Overhead pipework for overhead applicators might obstruct normal operations, or impose an undue load on the roof structure.

e) Overhead application might need supplementary low level application in order to provide coverage below large obstructions, such as aircraft in hangars.

f) Above ground pipework might be susceptible to damage by explosion.

g) Generally these systems are not suitable for use on water soluble liquid exceeding 25 mm in depth.

B-8 APPLICATION

The typical application of low expansion type of foam systems are illustrated below;

Sl No.	*Hazard*	*Low Expansion*
(1)	(2)	(3)
i)	Aircraft hangars	Yes
ii)	Cable tunnels	No
iii)	Flammable liquid storage tanks	Yes
iv)	Fuel transfer areas	Yes
v)	Liquefied natural gas	No
vi)	Liquefied petroleum gas (LPG)	No
vii)	Oil filled transformers and switchgear	Yes
viii)	Plastic packaging and storage	Yes
ix)	Plastic recycling	Yes
x)	Process areas	Yes
xi)	Refuse handling and storage	Yes
xii)	Rolled paper	No
xiii)	Tyre storage	Yes
xiv)	Warehouses – Classes A and B fuels	Yes

ANNEX C

(*Clause* 6.9)

ADDITIONAL INFORMATION ON FOAM CONCENTRATES

C-1 GENERAL

Foam concentrates are mixed with water to form a foam solution. Foam concentrates are either specific to the fuel or chemical that they are to protect or are specific to the type of discharge device through which the solution will be discharged.

C-2 MIXING RATE

Correct amount of foam concentrate needs to be mixed with water. The amount is normally shown on the container or drum containing the concentrate. The container will normally display a figure or combination of figures. Generally used percents for foams are 1 percent, 3 percent and 6 percent. The percent indicates how much foam concentrate is added to the water to make a solution. For a 1 percent foam, 1 part of foam concentrate and 99 parts of water. For a 3 percent foam, 3 parts of foam concentrate and 97 parts of water. For a 6 percent foam, 6 parts of foam concentrate and 94 parts water.

C-3 PROTEIN FOAM CONCENTRATE

These are available in general either as a 3 percent or 6 percent type concentrate. This type of concentrate is based on hydrolyzed protein, foam stabilizers and preservatives. It will produce highly stabilized air foam. Protein foam must always be used with an air aspirating type discharge device. Protein foam can become contaminated with fuel if plunged directly onto the fuel surface. Due to this, the application technique for protein foam becomes quite critical. The foam should be applied as gently as possible to the burning liquid surface. Protein foam, because of its stability, is relatively slow moving when used to cover the surface of a burning liquid.

C-4 FLUOROPROTEIN FOAM CONCENTRATE

Available in either as a 3 percent or 6 percent type of concentrate. This product is manufactured using the same method as protein but with the addition of fluorocarbon surfactants. The addition of these surfactants in the concentrate improves the performance of fluoroprotein foam over protein foam in two areas. It makes the fluoroprotein foam more resistant to fuel contamination/pickup and makes the foam blanket more mobile when discharged onto the flammable liquid. Because the fluoroprotein foam is more resistant to fuel contamination, it allows the discharging foam to be applied directly to the fuel surface and the foam blanket will not become saturated by fuel vapour. This type of foam can be used with a high back pressure foam maker by utilizing the sub-surface method of forcing expanded foam into the base of a cone roof storage tank containing a hydrocarbon fuel. The expanded foam enters the base of the storage tank then floats up through the flammable liquid to the surface where it covers the surface with a foam blanket. Fluoroprotein foam is also used in the hydrocarbon processing industry for storage tank firefighting. It is necessary to use with air-aspirating discharge devices with this foam application.

C-5 AQUEOUS FILM FORMING FOAM (AFFF)

Synthetic low-expansion foam concentrates are available in two types: standard AFFF's, and AR-AFFF (alcohol resistant aqueous film forming foam). Both the AFFF's are listed for their percent to be added to water to extinguish hydrocarbon or non-miscible fuels. These are available in either 1 percent, 3 percent or 6 percent type of concentrate. AFFF's are the most used foam concentrates for fixed systems. The 6 percent AFFF foams are not generally found due to the lack of hardware and discharge devices listed with them. The 6 percent AFFF foams are typically used by firefighters and are carried on fire trucks to be discharged through fire hoses.

AFFF foam solutions can be applied to a flammable liquid fire using either aspirating or non-aspirating discharge devices. The difference between the two is that the air-aspirating device entrains air and causes it to mix with the foam solution within the device. The non-air-aspirating device is incapable of this process. When flow rates and pressures are similar, AFFF solutions used with a non-air-aspirating discharge device will generally discharge/throw the foam a greater distance than the foam that is discharged from the air-aspirating discharge device. When using AFFF foams, application technique is not as critical as with proteins or fluoroproteins. AFFF foam can also be used successfully with the sub-surface injection method for standard hydrocarbon fuels and not for polar solvents and alcohol type fuels.

C-6 ALCOHOL RESISTANT AQUEOUS FILM FORMING FOAM (AR-AFFF)

These foams are unique because they are designed not only to extinguish hydrocarbon or non-miscible fuels or chemicals but also miscible fuels or chemicals. For fixed systems, the 3 percent AR-AFFF are being extensively with fixed proportioning devices, sprinkler heads, and other fixed discharge devices. When used on an alcohol fire, an air-aspirating nozzle will give a better performance over the non-air-aspirating nozzle. The increased expanded foam mass generated by the air-aspirating nozzle will give a more gentle application onto the surface of the alcohol liquid fire than will the non-aspirating nozzle.

C-7 FILM FORMING FLUORO-PROTEIN (FFFP)

This foam is a derivative of AFFF and fluoroprotein. Available in either as a 3 percent or 6 percent type of concentrate. These concentrates are based on fluoroprotein formulations to which an increased quantity of fluorocarbon surfactants has been added. These concentrates were developed to obtain the quick knockdown of AFFF with the added burn back resistance of standard fluoroprotein foam. It may be inferred that the efficiency of this concentrate lies somewhere between AFFF and fluoroprotein foam. These concentrates do not have the quick knockdown of the AFFF's when used on a spill fire. When used on fuel in depth fires they do not have the burn back resistance of fluoroprotein. FFFP foam can be generated with either air-aspirating or non-air-aspirating nozzles. When used through a non-air-aspirated nozzle they do not provide expansion ratios as good as AFFF when used through the same type of nozzle.

C-8 MEDIUM-EXPANSION FOAM

See IS 12835 (Part 2).

C-9 HIGH-EXPANSION FOAM

See IS 12835 (Part 2).

C-10 SHELF LIFE

Shelf life is the term used to describe the length of time which foam concentrates remain stable and usable without a significant change in their performance characteristics. The shelf life depends upon the composition of the concentrate, the ambient temperature storage range encountered, the container materials and if the concentrate is stored in its original container.

C-11 COMPATIBILITY

Compatibility is the ability of one foam concentrate to be mixed with another concentrate of the same type and proportioning ratio without altering the chemical, physical or performance characteristics of the mixed foam concentrates. All foams are compatible when applied on a fire simultaneously. However, they should not be mixed together.

C-12 ENVIRONMENTAL IMPACT AND TOXICITY

Approved foam concentrates are specifically formulated to provide maximum firefighting capabilities while at the same time providing minimal environmental impact and human exposure hazard. All concentrates are expected to be readily biodegradable both in the natural environment and in sewage treatment facilities. The concentrates are not considered primary or secondary skin irritants, however, prolonged contact may cause some dryness of the skin since they contain detergents.

ANNEX D

(*Clause* 9)

FOAM GENERATING METHODS

D-1 GENERAL

D-1.1 The process of producing and applying firefighting foams to the hazards require three separate operations as stated below, each of which consumes energy.

a) Foam proportioning process;

b) Foam generation phase; and

c) Foam distribution process.

Figure 7 shows the schematic of the relationship among the three operations stated above.

D-1.2 Normally, air foam generation and distribution occur simultaneously within the same device. There are several types of proportioning foam. The design and performance requirements of foam systems dictate the choice of types proportioning, generating, and distributing equipment for the protection of specific hazards.

D-2 FOAM CONCENTRATE PROPORTIONING SYSTEMS

D-2.1 General

All foam systems required a foam concentrate to be mixed with water in a specified correct proportion to provide a foam-making solution. Methods by which the same is achieved, are listed as follows:

a) By premixing the concentrate in water;

b) By induction of the concentrate into the water stream;

c) By displacement of the concentrate in the water stream; and

d) By injection of the concentrate into the water stream.

D-2.2 Premixed Foam Solution

This method involves mixing appropriate quantities of water and foam concentrate for storage as a premixed foam solution (premix). The foam system can then be supplied with premix when required either by pumping if the premix is stored in an atmospheric tank or by pressurisation if the premix is stored in a pressure vessel. Different types of foam have different shelf life as concentrate and premised. The following points are of great importance:

a) Foam concentrate should be suitable for storing for long periods as a premixed solution. Higher concentrations may sometimes be employed to reduced problems of deterioration that is by using a 6 percent concentrate at 10 percent solution strength.

b) High storage temperatures tend to accelerate any deterioration due to ageing of the solution.

c) Premix method usually employs a pressurised tank for the smaller risk where a quick acting automatic system is required. Nitrogen or carbon dioxide is generally used for expelling the tank contents.

D-2.3 Induction

In this method, the acceleration of a water stream through an inductor produces a fall in water pressure which is utilized to induce foam concentrate into the water stream in the required proportions. There are several arrangements available and each has a particular application. Some of the mostly adopted methods of induction are discussed in brief as under.

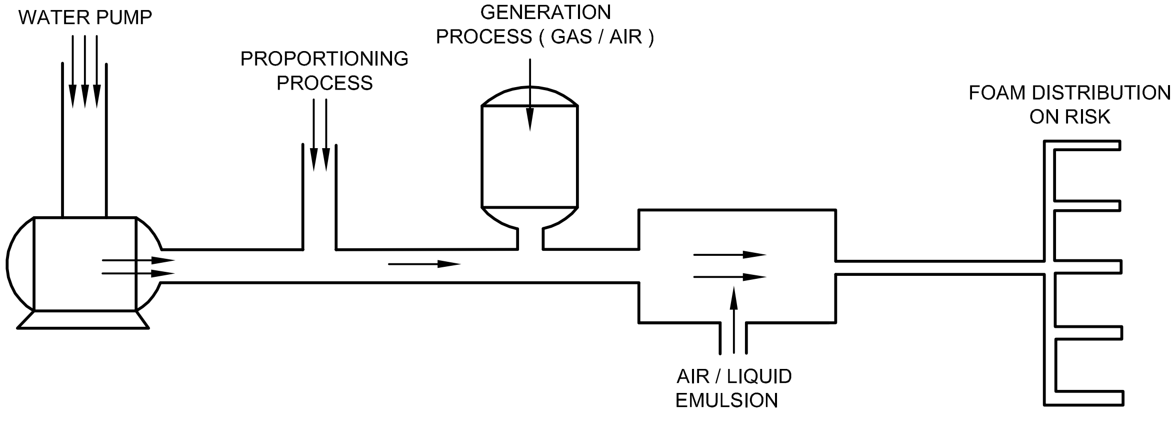


FIG. 7 SCHEMATIC ILLUSTRATION OF FOAM GENERATION

D-2.3.1 *Self Induction*

Self-inducting foam-making equipment incorporates a foam of inductor to draw in foam concentrate *via* an induction or pick-up tube (*see* Fig. 8). This arrangement may be referred to as 'end of line' induction. This method may be used for fixed or portable branch pipes and monitors. The following points are of great importance:

a) Concentrate should be made available at the nozzle; and
b) Bottom of the concentrate container generally should be not more than 2 m below the induction point. The length and size of the induction hose or pipe should depend upon the design of inductor.

D-2.3.2 *In-line Induction*

An inductor is arranged in the hose or pipework between the fire pump and the foam-making units, usually at some distance from the latter (*see* Fig. 9). Foam concentrate may therefore be introduced at a safe distance from the fire. Variation of concentration may be achieved by use of a manually controlled metering valve. The following points are of great importance:

a) In-line inductor should be suitable for the particular foam-maker with which it is to be used. The device is very sensitive to downstream pressures and is accordingly designed for use with specified length of hose or pipe between it and the foam-maker. Location of the foam-maker at a different level from the inductor also affects down-stream pressure. The pressure drop across the inductor is usually about one-third of the inlet pressure.
b) Bottom of the concentrate container generally should be not more than 2 m below the induction point. The length and size of the induction hose or pipe should depend upon the design of inductor.

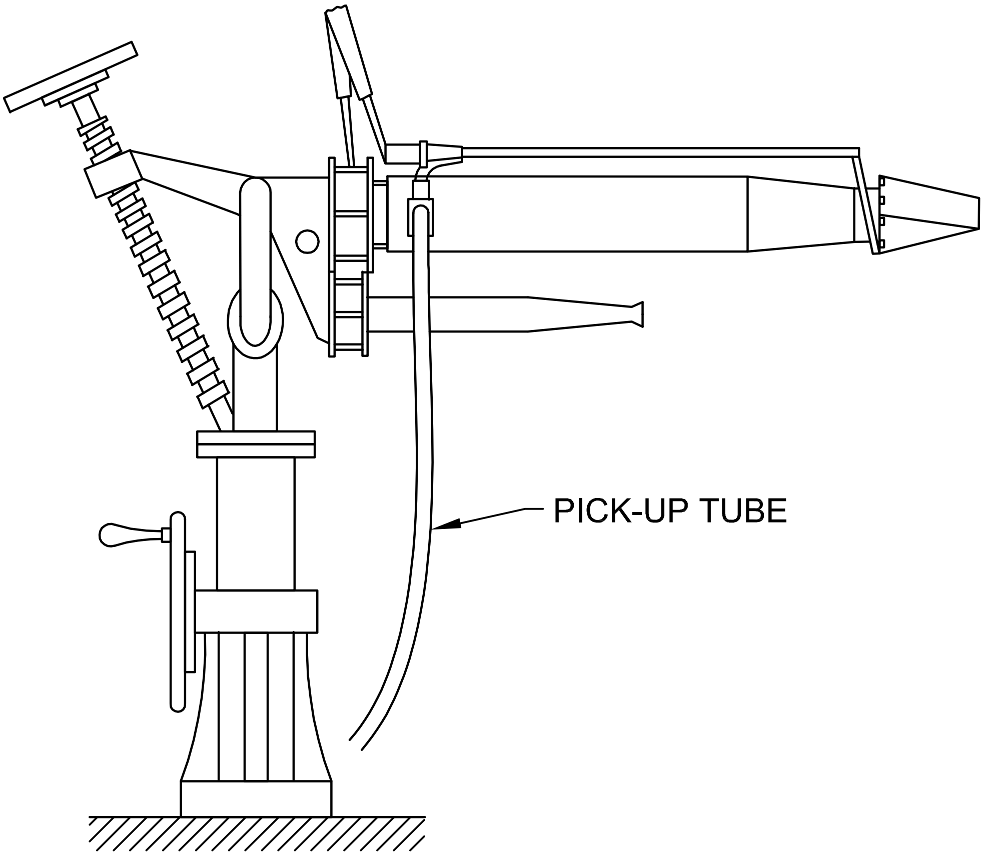


Fig. 8 Self-Inducting Foam Making Equipment

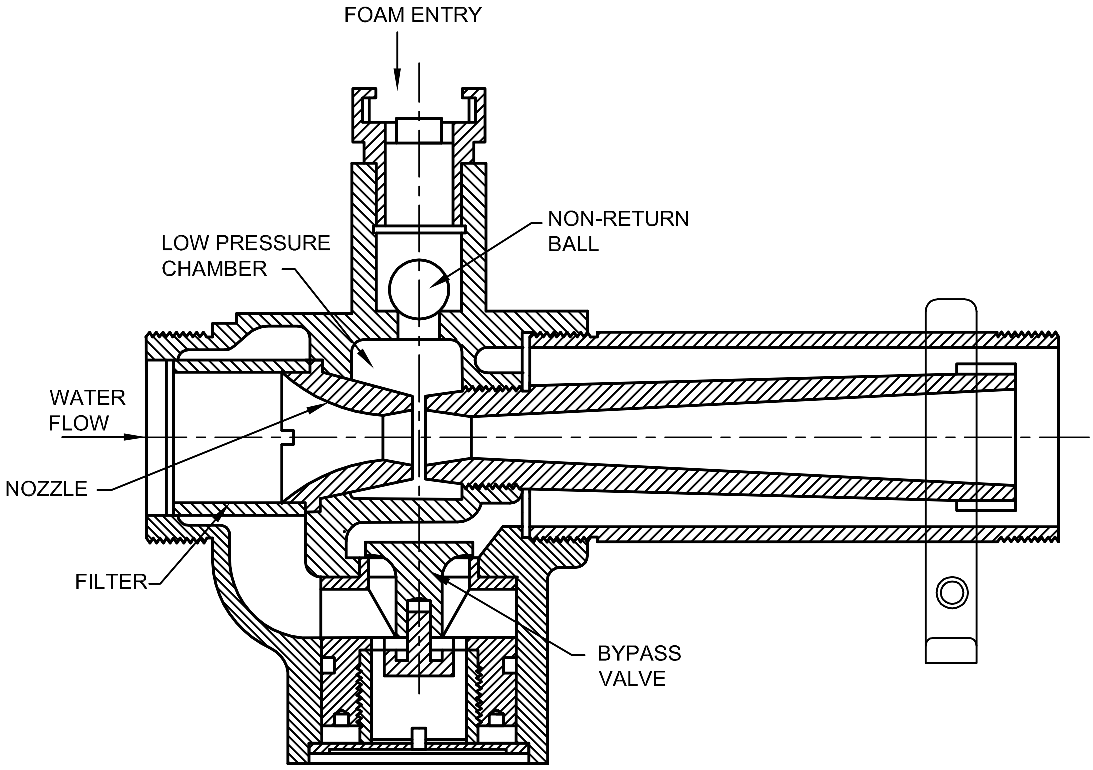


FIG. 9 IN-LINE INDUCTION FOAM MAKING EQUIPMENT

D-2.3.3 *Bypass Induction*

This method combines the best features of **D-2.3.1** and **D-2.3.2** without some of their disadvantages. A small proportion of the water being supplied to the system is diverted to an inductor positioned some distance upstream from the foam-maker (*see* Fig. 10). This inductor induces a highly concentrated solution which it discharges *via* a bypass line to the specially designed low pressure entry point below foam-making in the system where mixing the main stream reduces the concentration to the required value. The following points are of great importance:

a) Bypass inductor may be installed as much as 150 m from the foam-maker or 20 m below it as for use with jetty monitors. The size of piping should be as required.
b) Bottom of the concentrate container should be not more than 2 m below or 20 m below it as for use with jetty monitors. The size of piping should be as required.

D-2.3.4 *Around-the-Pump Induction*

This arrangement consists of an inductor installed in a bypass line between the discharge and suction of the fire pump (*see* Fig. 11). A small proportion of the water being applied to the system is diverted to the inductor, which draws the required quantity of foam concentrate from a container and delivers this as a highly concentrated solution to the pump suction where it is diluted by the main water stream to the required concentration. Concentration may be varied by use of a manually controlled metering valve. The following points are of great importance:

a) Care should be exercised when working the pump from a hydrant supply to ensure that the required inductor inlet to back pressure ratio is achieved. This is usually about 3 to 1. Equipment should be available to control the pump suction pressure automatically as the pump demand varies.
b) Foam proportioning is not sensitive to variations in system flow.
c) Bypass stream to the inductor is supplied from the pump discharge. This factor should be recognized in determining the net delivery of the water pump.
d) Bottom of the concentrate container should be not more than 2 m below the induction port. The length and size of the induction hose or pipe should be as required.

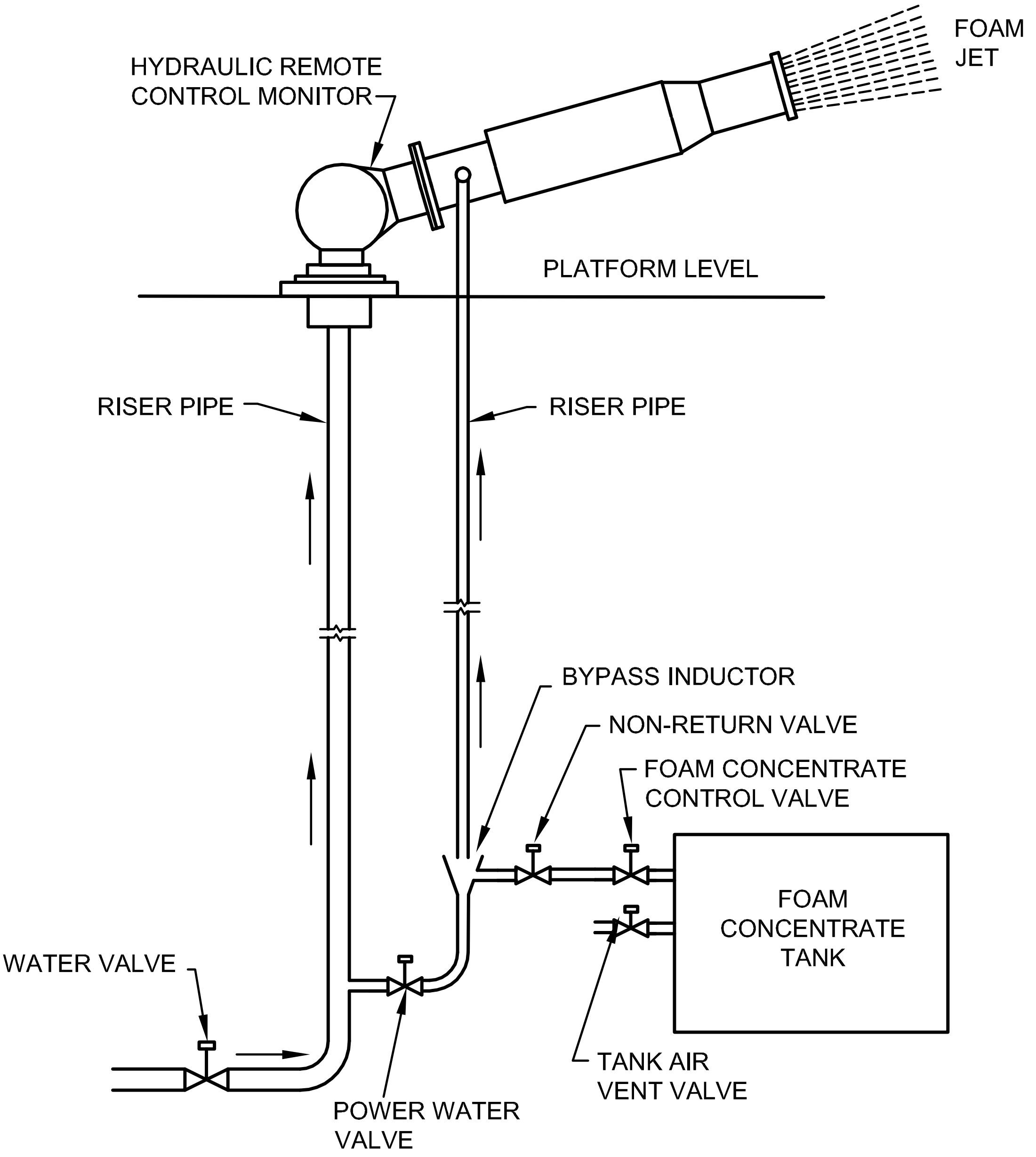


FIG. 10 BY-PASS INDUCTION FOAM MAKING EQUIPMENT

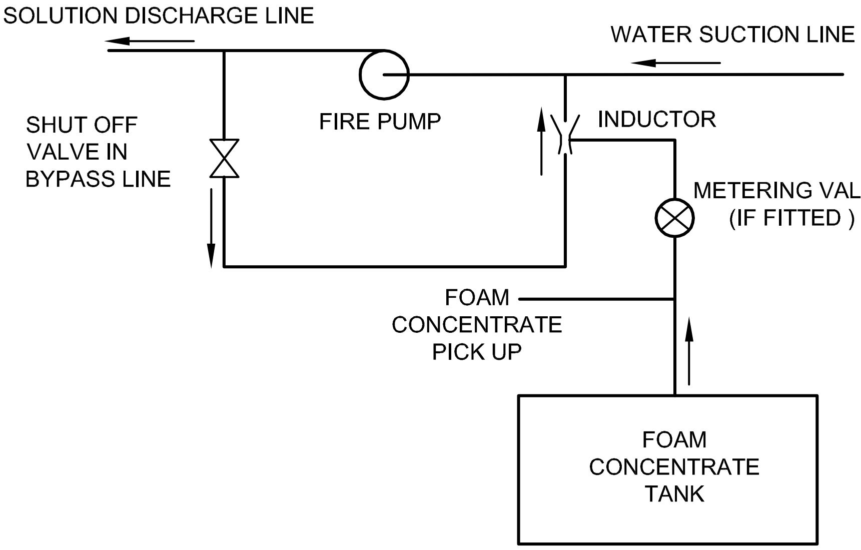


FIG. 11 AROUND THE PUMP INDUCTION FOAM MAKING

D-2.3.5 *Displacement Proportioner (Bladder Pressure Proportioning Tank)*

Foam concentrate is stored in a flexible bag within a pressure vessel. A device for producing a moderate pressure drop when the firefighting system is operating, has its high and low pressure sides connected to the pressure vessel in such a way that a feed from the high pressure side of the water supply flows into the vessel to displace the foam concentrate by applying pressure to the bag. The concentrate then flows to the low pressure side of the device where it mixes with the main water flow (*see* Fig. 12). A variety of arrangement may be used ranging from a single pressure vessel to a battery of vessels connected by a manifold. Twin vessels are often used so that when one is exhausted, the other may be operated. The first vessel is then recharged, thus securing continuous operation of the system. This arrangement is suitable for both large and small systems. The following shall also be considered:

a) Units are able to cater for a variation in water flow rates.
b) Pressure drop across the proportioner varies from 0.1 bar to 1.0 bar, depending upon the range of water flows.
c) Multiple units permit recharging with foam concentrate during operation, if this is required.

D-2.4 Injection

Foam concentrate is supplied to a metering device under a pressure greater than that of the water supply, by means of a foam pump. Several arrangements are available and each is suited to a particular application.

An orifice is used to provide a fixed flow of foam concentrate into the water stream. Alternatively a constant flow valve may be used to maintain accurate proportioning the system when the water of foam concentrate pressure vary. The following points are of significant importance:

a) System is suitable only for a fixed water flow rate; and
b) A separate pump is required to deliver the concentrate.

D-2.4.1 *Variable Flow Injection*

This unit is situated in the fire water main and is fed with foam concentrate at pressures higher than or equal to the water pressure (*see* Fig.13). Regulation of the concentration is effected automatically whether water or foam concentrate pressure vary or whether the water main flow varies.

D-2.4.2 *Balanced Pressure Proportioning*

By means of an auxiliary pump, foam compound is injected into the water stream passing through ratio flow controller (*see* Fig. 14). The resulting foam solution is then delivered to a foam-maker or play pipe. The inductor may be inserted in the line at any point between the water source and foam-maker or branch pipe. The following shall be considered:

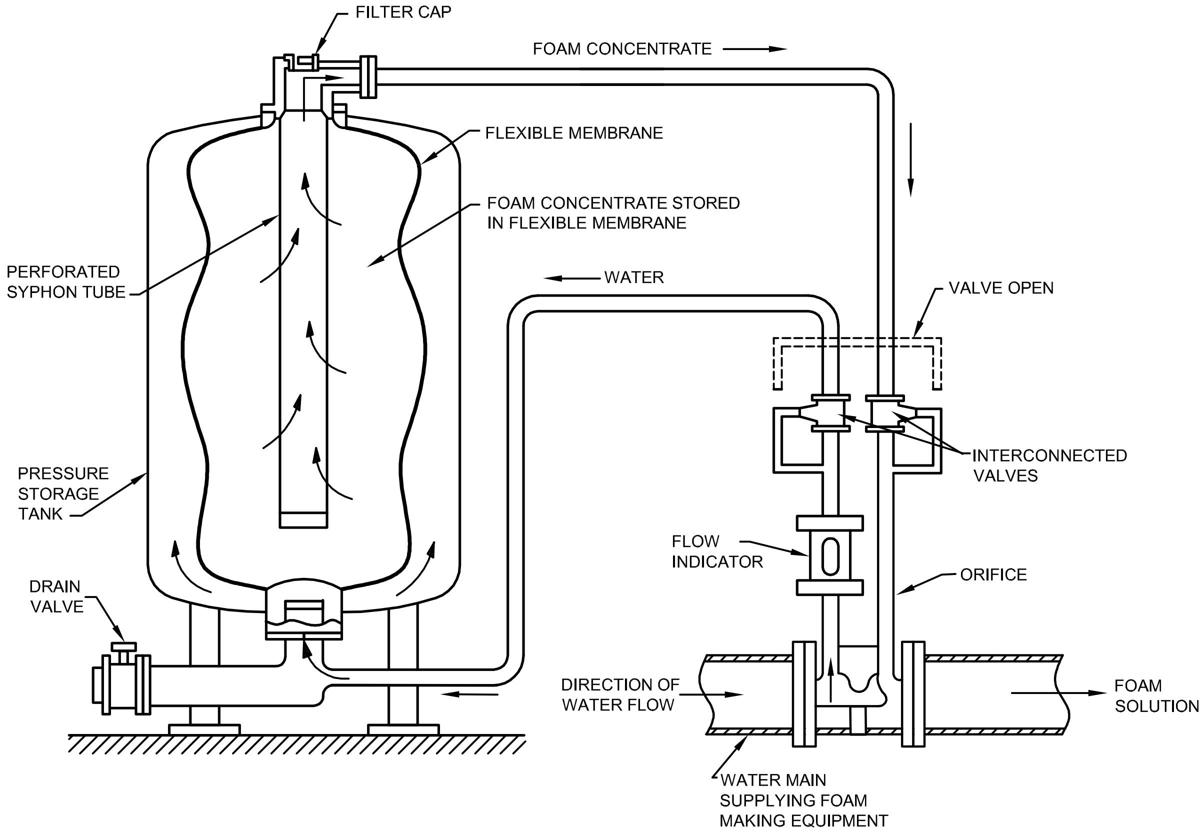


Fig. 12 Displacement Proportionate Tank

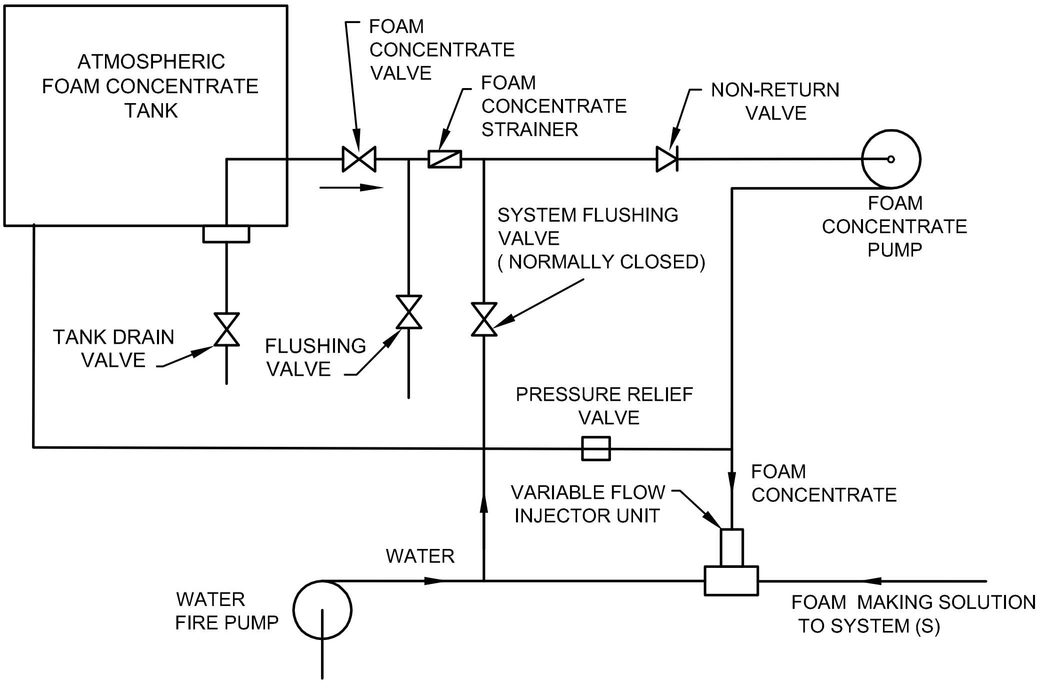

ATMOSPHERIC FOAM CONCENTRATE TANK
FOAM CONCENTRATE VALVE
FOAM CONCENTRATE STRAINER
NON-RETURN VALVE
FOAM CONCENTRATE PUMP
SYSTEM FLUSHING VALVE (NORMALLY CLOSED)
TANK DRAIN VALVE
FLUSHING VALVE
PRESSURE RELIEF VALVE
FOAM CONCENTRATE
VARIABLE FLOW INJECTOR UNIT
WATER
WATER FIRE PUMP
FOAM MAKING SOLUTION TO SYSTEM (S)

Fig. 13 Variable Flow Injection

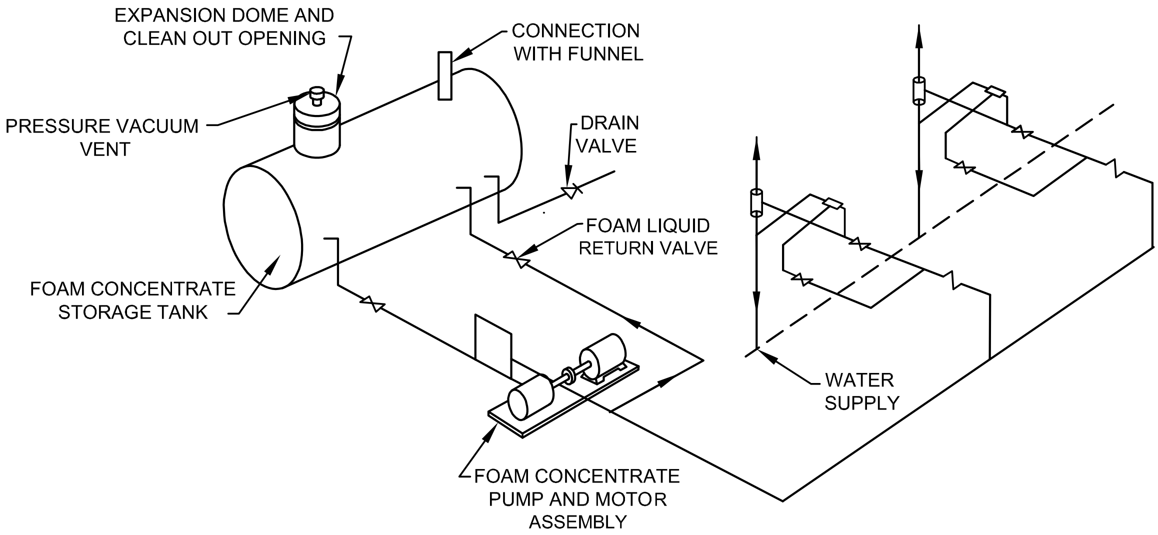

EXPANSION DOME AND CLEAN OUT OPENING
CONNECTION WITH FUNNEL
PRESSURE VACUUM VENT
DRAIN VALVE
FOAM LIQUID RETURN VALVE
FOAM CONCENTRATE STORAGE TANK
WATER SUPPLY
FOAM CONCENTRATE PUMP AND MOTOR ASSEMBLY

FIG. 14 BALANCED PRESSURE PROPORTIONING

a) Automatically maintains the desired concentration irrespective of either fluid operating pressure, provided that minimum recommended differential pressure is not exceeded.

b) Units are able to cater for flow ratios up to 10 to 1.

c) A separate pump is required to deliver the concentrates.

d) The water main pressure drop may be up to 1 bar, depending upon the flow ratio.

ANNEX E

(*Foreword and Clause* 5.1)

SUITABILITY OF DIFFERENT TYPES OF FOAM

Type of Foam	*Characteristic*	*Application*	*Suitable for*	
			Hydrocarbon	*Polar Solvent*
Protein Foam	a) Can be used at 3 percent and 6 percent concentrations b) Pre-mixable c) Low expansion foam adapted for all types of nozzles, Inductors, foam chambers and discharge units d) Good fire resistance and stability	a) Fires of Class A and B b) Mainly hydrocarbon fuel fires c) Fuel spills	Yes	No
Fluoroprotein Foam [FP]	a) Can be used at 3 percent and 6 percent concentrations b) Pre-mixable c) Low expansion foam d) Good fire resistance against re-ignition e) Oil repellent f) Can be directly sprayed on surface and also used for subsurface injection g) Good storage life	a) Fires of Class A and B b) Airport application c) Oil refineries d) Mineral oil fires e) Marine jetties	Yes	No

Type of Foam	*Characteristic*	*Application*	*Suitable for*	
			Hydrocarbon	*Polar Solvent*
Film Forming Fluoro-protein foam [FFFP]	a) Can be used at 3 percent and 6 percent concentrations b) Pre-mixable c) Low expansion foam d) Forms a vapour sealing film over the fuel e) Excellent fire resistance against re-ignition f) Can be directly sprayed on surface and also used for subsurface injection g) Long storage life h) Quick knockdown of fire	a) Fires of Class A and B b) Airport application c) Oil tankage d) Oil fires	Yes	No
Film Forming Fluoro-protein foam [FFFP] [Alcohol resistant]	a) Can be used at 3 percent concentration for hydrocarbon fires and 6 percent concentration for polar solvent fires b) Pre-mixable c) Low expansion foam d) Multi-purpose alcohol resistant e) Forms a rapid vapour sealing film over the fuel f) Excellent fire resistance against re-ignition g) Highly effective for hydrocarbon/polar solvent fires h) Produces a thick visible foam blanket with exceptional burnback resistance j) One product covers all types of risks. k) Long storage life	a) Fires of Class A and B b) Organic acids etc. c) Hydrocarbon and their blends d) Polar solvents	Yes	Yes
Aqueous Film Forming Foam [AFFF]	a) Can be used at 1 percent, 3 percent concentrations for hydrocarbon fires and 3 percent, 6 percent concentrations for polar solvent fires based on the type of concentrate b) Pre-mixable c) Low expansion foam d) Forms a vapour sealing film over the fuel e) Inhibits fuel flash f) Long storage life g) Quick knockdown of fire	a) Mineral oils b) Fuel spills c) Oil tanks d) Petrol stations e) Hydrocarbon flammable liquid fires	Yes	No

Type of Foam	*Characteristic*	*Application*	*Suitable for*	
			Hydrocarbon	*Polar Solvent*
Alcohol resistant-Aqueous Film Forming Foam [AR-AFFF]	a) Can be used at 3 percent concentration for hydrocarbon fires and 6 percent concentration for polar solvent fires b) Pre-mixable c) Low expansion foam d) Multi-purpose alcohol resistant e) Forms a rapid vapour sealing film over the fuel f) Excellent fire resistance against re-ignition g) Highly effective for hydrocarbon/polar solvent fires h) One product covers all types of risks. j) Long storage life	a) Polar solvents b) Organic acids, etc. c) Hydrocarbon and their blends d) Mineral oils	Yes	Yes
Synthetic foam	a) Pre-mixable b) Low, medium and high expansion foam concentrate depending on type of foam generator c) Fire extinction is achieved by rapid smothering and cooling	a) Cellars b) Storage areas c) Forest fires d) Hotel and tunnel fires e) Liquified gases like LPG and LNG, etc	Yes	No

ANNEX F

(*Foreword*)

COMMITTEE COMPOSITION

Fire Fighting Sectional Committee, CED 22

Organization	*Representative(s)*
Ministry of Home Affairs, New Delhi	Shri D. K. Shami (***Chairman***)
Agni Controls, Chennai	Shri D. Balachandran Shri Arun Kumar Balachandran (*Alternate*)
Airports Authority of India, New Delhi	Shri Subhash Kumar Shri P. K. Deshmukh (*Alternate*)
Bhabha Atomic Research Centre, Mumbai	Chief Fire Officer
CSIR-Central Building Research Institute, Roorkee	Shri R. S. Chimote Shri Suvir Singh (*Alternate*)
Central Industrial Security Force, New Delhi	Shri Rajnath Singh Shri A. K. Verma (*Alternate*)
Central Public Works Department, New Delhi	Shri Chaitanya Kumar Verma Shri D. K. Tulani (*Alternate*)
Centre for Fire & Explosive Environment Safety (DIFR), New Delhi	Shri M. K. Jain Shri Amit Saini (*Alternate*)
Chennai Petroleum Corporation Ltd, Chennai	Shri J. P. K. Hepat
Chhatariya Rubber & Chemicals Industries, Mumbai	Shri S. A. Haveliwala Shri H. S. Haveliwala (*Alternate*)
City and Industrial Development Corporation	Shri Arvind P. Mandke
Directorate General of Quality Assurance, Ministry of Defence, Pune	Controller QA (FE) Joint Controller QA (FE) (*Alternate*)
Delhi Fire Services, New Delhi	Director Chief Fire Officer (*Alternate*)
Directorate of Fire and Emergency Services, Goa	Shri Ashok Menon Shri Nitin V. Raiker (*Alternate*)
Engineers India Ltd, New Delhi	Shri R. B. Bhutda Shri Vipan Goel (*Alternate*)
F.M. Engineering International India Branch, Bengaluru	Shri Srikanth Yajjala Shri Manikandan Krishnamoorthy (*Alternate*)
Fire & Emergency Services, J&K, Srinagar	Shri V. K. Singh Shri Bashir Ahmed Shah (*Alternate*)
Fire & Security Association of India, Chennai	Shri Anas Rizwi
Fire Protection Association of India, Mumbai	President
GAIL (India) Limited, New Delhi	Shri S. P. Garg Shri Sanjeev Kumar Kalkal (*Alternate*)
Gunnebo India Pvt Limited, Thane	Shri Ashutosh Satpute Shri Gajanan Medewar (*Alternate*)
H. D. Fire protect Pvt Limited, Thane	Shri Harish N. Dharamshi Shri K. T. Chaudhari (*Alternate*)
Indian Oil Corporation Limited, Noida	Shri Aashish R. Gokhale
Institution of Fire Engineers, New Delhi	President General Secretary (*Alternate*)

Organization	*Representative(s)*
Johnson Controls (India) Pvt Ltd, Gurugram	Shri Santosh Muzumdar Shri Nitin Rastogi
K. V. Fire Chemicals (India) Pvt Ltd, Navi Mumbai	Shri Rajesh H. Sabadra Shri Uday K. Shroff (*Alternate*)
Karnataka State Fire and Emergency Services, Bengaluru	Shri K. U. Ramesh Shri K. Srinivasa (*Alternate*)
Maharashtra Fire Services, Mumbai	Shri S. S. Warick
Military Engineer Services, Engineer-in-Chief's Branch, Integrated HQ MoD (Army), New Delhi	Shri Sanjay Sharma Shri A. K. Dubey (*Alternate*)
Mumbai Fire Brigade, Mumbai	Shri P. S. Rahangdale Shri H. D. Parab (*Alternate*)
National Association of Fire Officers, Mumbai	President
National Building Construction Corporation Ltd, New Delhi	Shrimati Sunita Purswani Shri R. K. Agarwal (*Alternate*)
Nohmi Bosai (India) Pvt Ltd, Gurugram	Shri Ishwar Iyer
Oil Industry Safety Directorate, New Delhi	Shri S. K. Nandy
Reliance Industries Limited, Mumbai	Shri Varadendra Koti Shri Umesh Khandalkar (*Alternate*)
RESQ Technologies, Ahmedabad	Shri Rohit V. Shah
Safex Fire Services Limited, Mumbai	Shri Jitendra Shah Shri Sandip Shah (*Alternate*)
Shah Bhogilal Jethalal & Bros, Ahmedabad	Shri Mukesh M. Shah Shri Abhay D. Purandare (*Alternate*)
State Bank of India, Mumbai	Shri Vinayak Gokhale
Surex Production and Sales Private Limited, Kolkata	Shri Debashis Neogi
Swastik Synergy Engineering Pvt Ltd, Mumbai	Shri Mukesh D. Shah Shri Kunal Zatakia (*Alternate*)
Tamil Nadu Fire and Rescue Services Department, Chennai	Shri S. Vijayasekar Shrimati N. Priya (*Alternate*)
The Supreme Industries Ltd, Mumbai	Shri Kisan Kundalkar Shri G. K. Saxena (*Alternate*)
UL India Pvt Limited, Bengaluru	Shri Suresh Shanmugam Shri S. P. Tej Kumar Behara (*Alternate*)
Uttar Pradesh Fire Services, Lucknow	Shri P. K. Rao Shri Aman Sharma (*Alternate*)
West Bengal Fire and Emergency Service, Kolkata	Shri Abhijit Pandey Shri Kamal Nandy (*Alternate*)
In Personal Capacity (*B-152, Ist Floor, East of Kailash, New Delhi*)	Shri Hemant Kumar
In Personal Capacity (K-*33-A, Green Park, New Delhi*)	Shri S. K. Dheri
In Personal Capacity (*A-45, Sector-70, Noida*)	Dr H. S. Kaprwan
In Personal Capacity (*D-317, 2nd Floor, Nirman Vihar, New Delhi*)	Shri R. C. Sharma

Organization	*Representative(s)*
In Personal Capacity (*27A, Tapovan Senior Citizens Foundation, Coimbatore 641 010*)	Shri T. R. A. Krishnan
BIS Directorate General	Shri Sanjay Pant, Scientist 'F' and Head (Civil Engineering) [Representing Director General (*Ex-officio*)]

Member Secretary

Shri S. Arun Kumar
Scientist 'E' (Civil Engineering), BIS

Fire Detection Alarms and Suppression System Subcommittee, CED 22:4

Organization	*Representative(s)*
Ministry of Home Affairs, New Delhi	Shri D. K. Shami (***Convener***)
Agni Controls, Chennai	Shri D. Balachandran Shri Selvakumar Balachandran (*Alternate*)
ASTRAL Polytechnik Ltd, Ahmedabad	Shri Ritesh Patel Shri Manoj Dhar (*Alternate*)
Bhabha Atomic Research Centre, Mumbai	Chief Fire Officer
CSIR-Central Building Research Institute, Roorkee	Shri Rajiv Goel Shri R. S. Chimote (*Alternate*)
Central Public Works Department, New Delhi	Shri Chaitanya Kumar Verma Shri D. K. Tulani (*Alternate*)
Central for Fire Explosive Environment Safety, (DRDO), Delhi	Shri M. K. Jain Shri Amit Saini (*Alternate*)
Chennai Petroleum Corporation Limited, Chennai	Shri J. P. K. Hepat
Directorate General of Quality Assurance, Ministry of Defence, Pune	Col V. V. Kadam Col N. K. N. Rao (*Alternate*)
Delhi Fire Service, New Delhi	Director Chief Fire Officer (*Alternate*)
DSPA Fire Suppressions India Pvt Ltd, Pune	Shri Chetan Udgir
EAST Corp, Thane	Shri Hemant Khadse
Engineers India Ltd, New Delhi	Shri Vipan Goel Shri R. B. Bhutda (*Alternate*)
FOGTEC Brandschutz GmbH & Co KG, Mumbai	Shri Jackson Jose
F. M. Engineering International India Branch, Bengaluru	Shri Srikanth Yajjala Shri Manikandan Krishnamoorthy (*Alternate*)
FYRPROTEK (Fire Engineers & Consultants), New Delhi	Shri Gulshan Khurana
Gunnebo India Pvt Limited, Thane	Shri Ashutosh Satpute Shri Gajanan Medewar (*Alternate*)
Honeywell International (I) Pvt Ltd, Bengaluru	Shri Mandar Sawant Shri Akhand Kumar (*Alternate*)
Institution of Fire Engineers (India) Ltd, New Delhi	President General Secretary (*Alternate*)
Maple Engineering Design Services (India), Pvt Ltd, Bengaluru	Shri B. S. A. Narayan Shri H. R. Rangannath (*Alternate*)

Organization	*Representative(s)*
Municipal Corporation of Greater Bombay, Mumbai	Chief Fire Officer Deputy Fire Officer (*Alternate*)
Newage Industries, Mumbai	Shri Ashok M. Shah Shri Shetul A. Shah (*Alternate*)
Nitin Fire Protection Industries Ltd, Mumbai	Shri Nitin M. Shah Shri Pravin Shah (*Alternate*)
Nohmi Bosai (India) Pvt Ltd, Gurugram	Shri Ajit Raghavan (*Alternate*)
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Johnson Controls (India) Private Limited, Gurugram	Shri Santosh Muzumdar Shri Ashish Dileep Sawant (*Alternate*)
West Bengal Fire and Emergency Service, Kolkata	Representative
In Personal Capacity (*A-45, Sector-70, Noida*)	Dr H. S. Kaprwan
In Personal Capacity (*D-317, 2nd Floor, Nirman Vihar, New Delhi*)	Shri R. C. Sharma
In Personal Capacity (*27A, Tapovan Senior Citizens Foundation, Coimbatore 641 010*)	Shri T. R. A. Krishnan
In Personal Capacity (*K-33-A, Green Park, New Delhi*)	Shri S. K. Dheri
In Personal Capacity, (*A-59, Sector 35, Noida*)	Shri Kanwar A. Singh

(*Continued from second cover*)

Latest trends in the design and installation of foam systems have been considered and drafted according the prevailing capabilities in the country. One percent foam is being considered for the first time for particular type of foam which is being increasingly used worldwide to fight high hazard tank farm fires.

The composition of the Committee responsible for the formulation of this standard is given in Annex F.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test, or analysis shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.gov.in

Regional Offices: *Telephones*

Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg
NEW DELHI 110002
2323 7617
2323 3841

Eastern : 1/14 C.I.T. Scheme VII M, V.I.P. Road, Kankurgachi
KOLKATA 700054
2337 8499, 2337 8561
2337 8626, 2337 9120

Northern : Plot No. 4-A, Sector 27-B, Madhya Marg
CHANDIGARH 160019
265 0206
265 0290

Southern : C.I.T. Campus, IV Cross Road, CHENNAI 600113
2254 1216, 2254 1442
2254 2519, 2254 2315

Western : Manakalaya, E9 MIDC, Marol, Andheri (East)
MUMBAI 400093
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